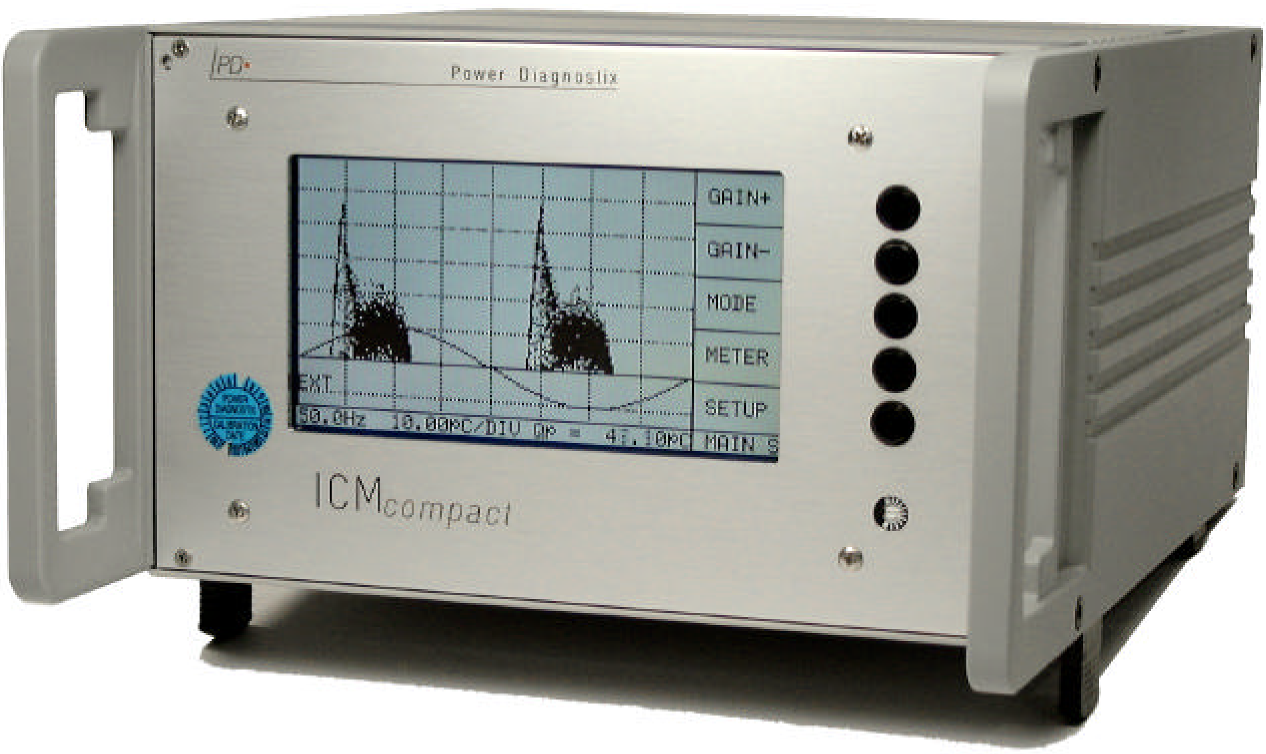
ICM*compact*

Partial Discharge Detector



User Manual

Vers. 2.07

Contents

I General

I.1 About this Manual

This manual describes the hardware, software and usage of the ICM*compact* in its current version. Some of the hardware features of the most recent versions are not available with earlier versions of the instrument. It is possible to upgrade most of the previous instruments to the features of the current instruments. Please contact Power Diagnostix for details.

Software updates are available through Power Diagnostix's web site (www.pdix.com). The access to the download area of that Web Site is password protected and requires a valid software maintenance contract. Contact Power Diagnostix for details. Revisions of this manual and current brochures are available for download (Adobes PDF-Format) through that Web Site as well.

This manual describes the ICM*compact* including its miscellaneous functions. These functions have to be ordered separately and are marked as optional functions. For information regarding the accessories and special applications of the ICM*compact* please contact Power Diagnostix

I.2 Instrument Safety

Before using the ICM*compact*, read the following safety information and this manual carefully. Especially read and obey the information, which are marked with the words 'Warning' and 'Caution'. The word 'Warning' is reserved for conditions and actions that pose hazards to the user, while the word 'Caution' is reserved for conditions and actions that may damage the instrument, or its accessories, or that may lead to malfunction.

Always obey the safety rules given with the warnings and with this chapter. Especially take care of the safety issues while performing field measurements. Never disregard safety considerations even under time constraints found often with on-line and off-line test on site.

Warning:

- Always provide solid grounding of the instrument and the coupling units. Use the rear side wing nut terminal for ground connection (System Ground see II.1.2) Never operate the instrument without protective grounding.
- Use isolation techniques, such as isolation transformers or fiber optic isolation to avoid hazard and injury. With applications bearing a high risk of electrical shock or breakdown use fiber optic isolation in general.
- Avoid working alone.
- Do not allow the instrument to be used if it is damage, or its safety is impaired.
- Inspect the ground leads and signal cables for continuity.
- Select the proper coupling circuit and connection for your application.
- Do not use the instrument in condensing or explosion endangered environment.

I.3 Principle of Operation

The ICM*compact* partial discharge detector is designed for quality assurance and quality control tests of high, medium and low voltage insulation in a test laboratory environment. The instrument may be adapted to non conventional testing tasks such as field testing and diagnostics by use of various preamplifier and couplers. The standard set (Fig.1, red marked) of the ICM*compact* consists of a coupling unit CIL4L, a preamplifier RPA1 and the instrument.

The ICM*compact* partial discharge detector is an autonomous instrument. Simple screen shots and storage of results can be done by means of the optional serial interface and a PC program. A precise evaluation of the measurements is possible using databases, specific knowledge bases or getting in contact with Power Diagnostix' people. For tasks requiring extended computer control, protocol functions and data manipulation we recommend the ICM*system*.

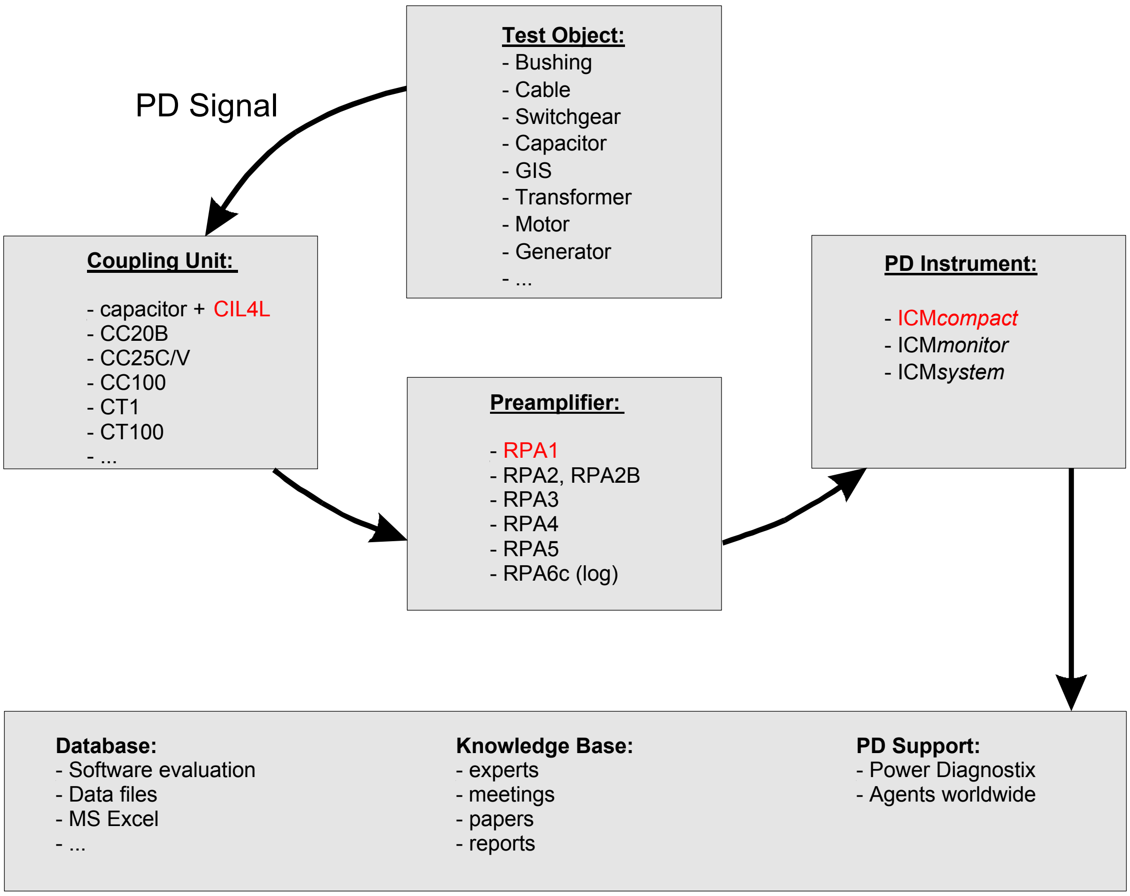


Fig. 1: Principle PD Measurement

The ICM*compact* is easy to use. The operator can choose between several display modes of the integrated LCD screen, e.g. meter display, scope display or partial discharge pattern display. All instrument settings including calibration are done via the on-screen menus by pushing the five buttons on the right side of the instrument. These settings are automatically stored in a non volatile memory when the system is shut down. The following section describes the use of the ICM*compact* PD detector.

II Installation

II.1 The Acquisition Unit

The standard ICM*compact* package includes the partial discharge detector, the remote controlled preamplifier and the standard coupling unit CIL4L. All PD detectors of Power Diagnostix' are build on a modular concept. Therefor it is possible to vary all external accessory parts like i.e. coupling units, preamplifiers or calibration impulse generators. For more details about all accessories please contact Power Diagnostix. It depends on each application, what kind of combination for coupling unit and preamplifier will bring best results.

Fig. 2 shows a photo of the front view of the instrument in a half 19" rack. The backlit liquid crystal display has a resolution of 240x128 pixels.

Fig. 2: ICM*compact* (Photo)

The five control buttons are arranged to the right hand side of the LCD panel. The brightness adjustment of the LCD is accessed using a small screwdriver, immediately beneath the control buttons. A temperature deviation of the environment will be compensated by the device itself.

On the rear panel of the standard (19½" wide) instrument are found the BNC connectors for signal input (AMP IN), the strip chart recorder output (REC OUT), the input for external synchronization (SYNC IN) and the optional serial connector (REMOTE).

The instrument operates with mains supply in the range from $85V_{AC}$ up to $264V_{AC}$ @ 47 to 440Hz. The standard preamplifier RPA1 is connected to the AMP IN terminal with a normal 50Ω coax cable, i.e. RG58. The amplified partial discharge signals as well as supply voltage and remote control signals to the preamplifier are carried via this cable. The RPA1 acts as a 50Ω line driver and thus significantly increases overall sensitivity when working with longer cables (up to 200m). Furthermore, the RPA1 enhances the sensitivity of the coupling unit, essentially acting to match it to connecting cable impedance. This requires that the RPA1 be connected as close as possible to the coupling unit.

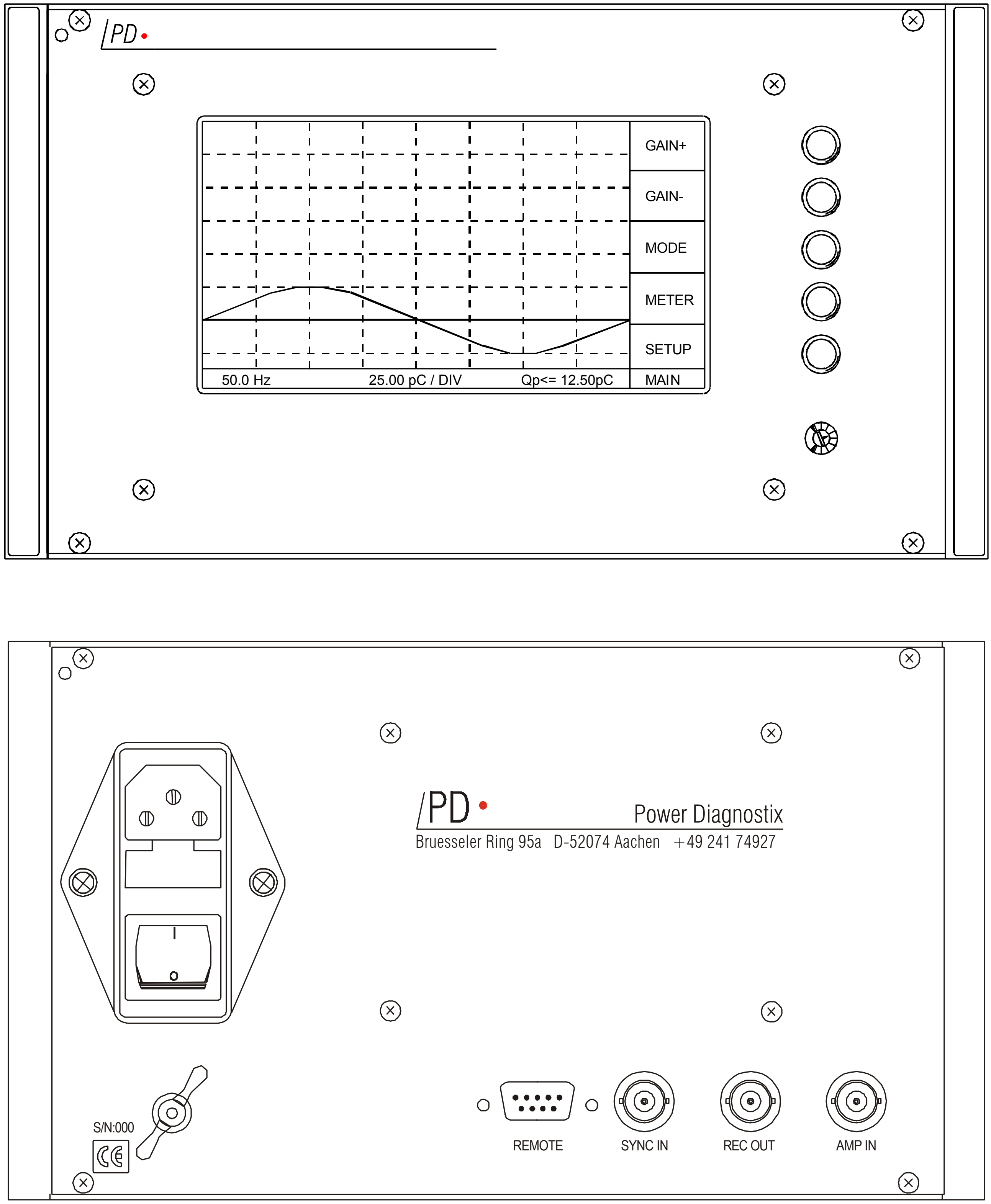


Fig.3: Front Panel (top) and Rear Panel (bottom) of the ICM*compact*

The CIL4L standard coupling unit is a so-called RL coupling unit (inductance-resistance), which is tuned to coupling capacitors in the range of 600pF to 2500pF. Its permissible maximum charging current is 50mA. Other coupling units can be supplied by Power Diagnostix on request.

Fig.4 and Fig.5 display the standard preamplifier and standard coupling unit for the ICM*compact.*

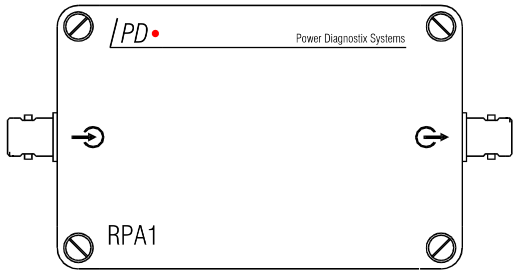


Fig: 4 Preamplifier RPA1

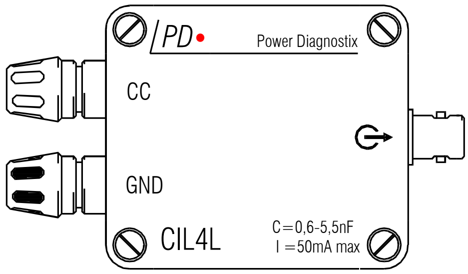


Fig: 5 Quadrupole CIL4L

II.1.1 Optional Functions for the ICM*compact*

The instrument can be equipped with several optional features as:

- VLF option (very low frequency) allows measurements with 0.1Hz, 0.05Hz, and 0.02Hz. This option requires also the HVM extension for the automatic voltage synchronization.
- Additional DSO board for Cable Fault Location. Single PD pulses and their echo's are captured with a high sampling rate to localize faults in long cables. The extended software version stores and analyzes the data (see also chapter III.3.3 and VI).
- Additional voltage measurement and display, HVM Display (see also chapter III.3.1).
- Extended synchronization frequency up to 510Hz.
- MUX The channel multiplexer allows a manual switching between 4 or 12 different PD sources.
- AUX The auxiliary inputs record further data like power, temperature, speed (III.3.5).
- STP A quick change of 12 different setups including the calibration data (III.3.6).
- LOG Offers a logarithmic scaling for broad range PD signals (III.3.7).
- Remote control interface (RS232). Serial hardware link to the software packages.
- Software Driver. If the ICM*compact* should be controlled by others than the original software, a driver for 'C' is available. This driver is only useful for software programming. (on request)
- Fiber Optic Link (FOL) for the serial interface RS232. Offers a safe insulation and an extended distance between ICM*compact* and the PC/Laptop.
- Fiber Optic Link (FOL) to the preamplifier (RPA4). Allows measurements on the high voltage side and safe insulation to the measurement unit.
- TTL-Gating input. Via a BNC connector at the rear panel, a TTL-signal allows to blind out disturbance signals (see also chapter III.5.3).
- Analog Gating input. Allows to capture disturbance signals via an extra preamplifier (preferably the logarithmic RPA6) which is used to blind out the noise signal (see also chapter III.5.4).
- Current output. A signal of 4-20mA equivalent to the calculated charge, is provided on the rear panel.
- Full 19" wide box to fit the ICM*compact* into a standard rack.

- Software packages. Two software packages to communicate via a PC are available. (see also chapter IV):
  - ICM*compact* — Standard software to record PD measurements and create report documents. Optional version for the cable fault location, only to use with the DSO.
  - HV*pilot* — Used for voltage control and taking measurements over long periods in combination with the STEP*compact.*

II.1.2 Connections

There are various circuits to take measurements of PD with the ICM*compact*. The diagram below (Fig. 6) illustrates the basic connections among the elements of the partial discharge measuring setup with the ICM*compact.* Here the coupling device (CIL4L) is put in series with the coupling capacitor. So the test object can be connected in parallel to the coupling capacitor and the voltage supply.

Caution: The **AMP IN** is only to be connected with the preamplifier or a Spectrum Analyzer. The supply voltage for the preamplifier may damage the output circuit of the signal source. Be sure not to connect anything but a RPA to this terminal or to turn OFF the supply voltage. Only the **SYNC IN** terminal can take voltages up to ~200V_{peak}. Do not apply any voltage to the **REC OUT** terminal (min. 100 Ω input impedance).

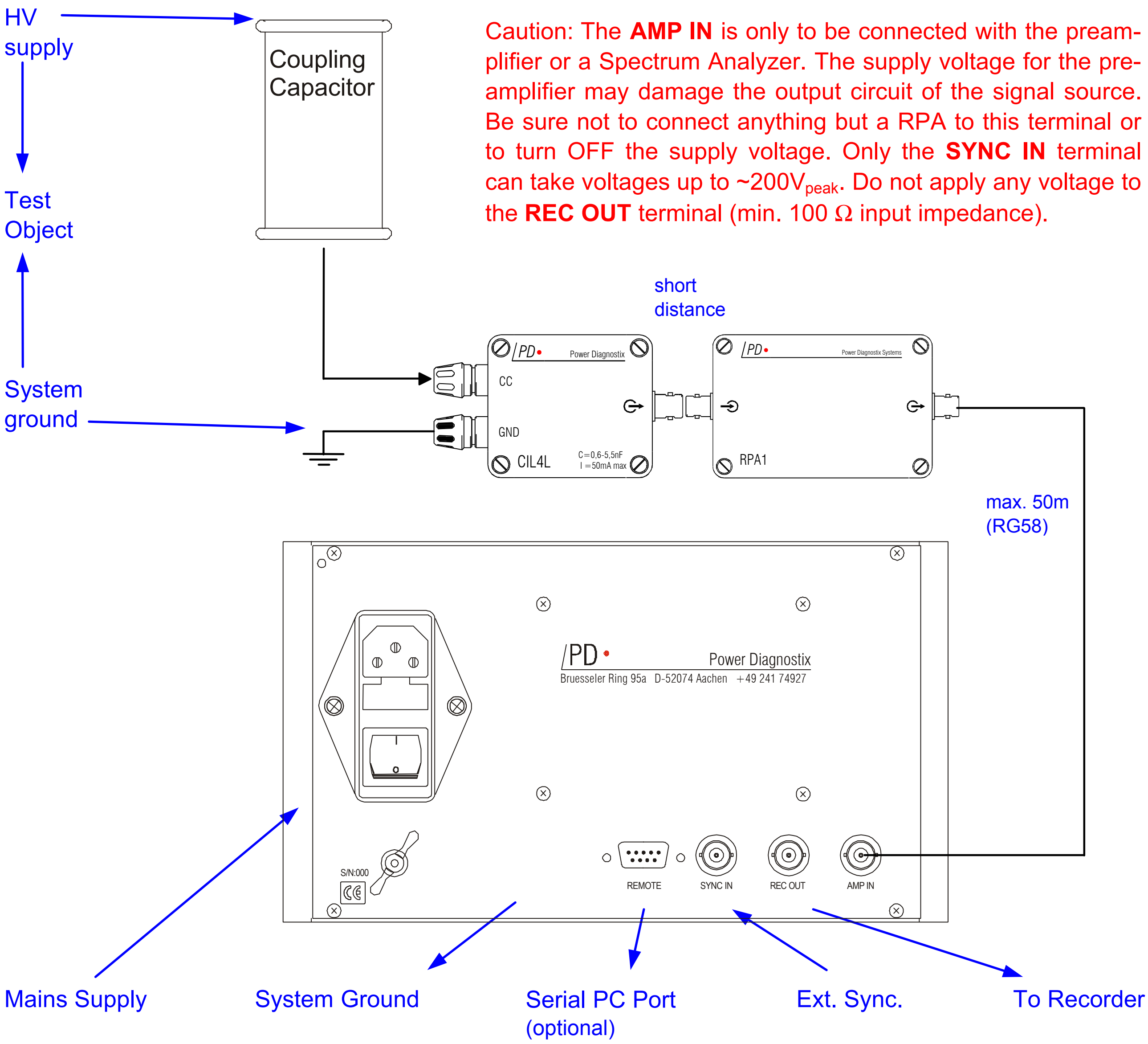


Fig. 6: Basic connections for PD measurement on a test set up. (Not drawn to scale).

In order to prepare a measurement, connect the input (CC) of the coupling unit CIL4L to the low side terminal of the coupling capacitor and the ground input (GND) of the coupling unit to ground. The output of the coupling impedance is directly connected to the RPA1 preamplifier preferably using a BNC/BNC adapter or a short length of BNC cable, this minimizes the capacitive loading of the coupling unit and exploits the relatively high input impedance (10kΩ//50pF) of the RPA1. The quality of the connecting cable between the RPA1 output and the ICM*compact* display unit (AMP IN) is fairly uncritical. Up to lengths of 50m we recommend normal RG58 BNC cable; RG213 cable (having a lower attenuation) is recommended for lengths up to 200m.

II.1.2.1 Synchronizing the ICM*compact*

In the absence of an external synchronization signal, the ICM*compact* will automatically synchronize to the sine wave of the line voltage supplying power to the ICM*compact* itself. Often, the high voltage applied to the test setup is not in phase with the line votlage and may not even be the same frequency as the line voltage. In such cases, it is best to synchronize the ICM*compact* with an external signal.

To synchronize the ICM*compact* on the high voltage applied to the test setup, a voltage divider is needed to create a copy of the voltage wave. The SYNC IN input is designed for voltage in the range of 1V to $100V_{RMS}$ (max. $200V_{peak}$). Regard, the input impedance of the SYNC IN input is about Z_{in} = 1MΩ//200pF. With the optional VLF function switched on it's about 10MΩ.

If you use a coupling unit from Power Diagnostix, either quadrupole or capacitor with a built in quadrupole, the once with the extension .../V (like CC25C**/V** or CIL4M**/V**) will have an extra output labeled 'U'. Connect this low-voltage copy of the applied voltage to the SYNC IN connection on the rear of the ICM*compact*. Additionally, a TTL type trigger signal can be supplied to the SYNC IN connection to force synchronization.

The connections to the ICMcompact are made on the rear panel of the instrument, to the four BNC connectors, one wing nut screw, and one serial connector. The functions of the connectors are as follows:

AMP IN: The AMP IN BNC connector is where the PD signal enters the ICM*compact*. The AMP IN connector must be connected to a remote preamplifier (RPA). Notice the direction of the arrows engraved on the RPA; the arrows must point **toward** the ICM*compact*.

RPA: The output arrow engraved on the RPA (preamplifier) must be connected to the AMP IN of the ICM*compact.* The input arrow of the RPA must be connected to the output of a quadrupole (measuring impedance) or other PD signal sources (such as a current transformer).

The connection between the output of the coupling impedance and the RPA1 preamplifier should be with a BNC/BNC adapter or a short length of BNC cable, in order to minimize the capacitive loading of the coupling unit and fully benefit from the relatively high input impedance (10kΩ//50pF) of the RPA1. The quality of the connecting cable between the RPA1 output and the ICM*compact* display unit (AMP IN) is fairly uncritical. Normal RG58 BNC cable is recommended for lengths up to 50m; RG213 cable (which has a lower attenuation) is recommended for lengths up to 200m.

Quadrupole: The quadrupole captures the PD signal from the coupling capacitor, or alternatively, from the test object itself. Power Diagnostix offers quadrupoles as separate modules or as built-in components of coupling capacitor units. The output of the quadrupole must be connected to the input of a preamplifier. The input marked “CC” must be connected to the low side of the coupling capacitor (or alternatively to the low side, or neutral, of the test object). The terminal marked “GND” must be connected to the system ground.

If the quadrupole has an optional voltage divider, the output marked “U” is a low-voltage copy of the high voltage applied to the test object and coupling capacitor. This output can be used for external synchronization when connected to the “SYNC IN” terminal of the ICM*compact*.

REC OUT: The REC OUT terminal of the ICM*compact* may optionally be connected to a paper recorder or other device to provide a graph of the average charge magnitude. For the output level see chapter III.2.3 table 1.

SYNC IN: The SYNC IN can optionally be used for external synchronization of the ICM*compact* to the frequency of the applied high voltage. This can be the output of a voltage divider (such as the voltage divider included with some Power Diagnostix quadrupoles) or of some other customized circuit. If the SYNC IN is not connected, the ICM*compact* will synchronize on the mains supply frequency (usually 50 or 60 Hz).

REMOTE: The REMOTE terminal provides the optional serial connection to a personal computer for remote communications, using the serial cable provided by Power Diagnostix.

Mains supply: The mains (power supply) plug must be connected to a power outlet providing power in the voltage range $85V_{AC}$ up to $264V_{AC}$, frequency 47 - 440Hz. The on/off switch for the unit is located above the mains plug. A power supply fuse is located between the on/off switch and the mains power inlet.

GND: The wing nut on the rear panel of the ICM*compact* must be connected to ground.

GATE IN (optional)**:** The GATE IN terminal, which is not included in all models of the ICM*compact*, can be used for noise rejection during measurements. To do so, connect the output of an additional RPA, carrying the unwanted noise signal, to the GATE IN.

The minimum connections that must be made in order to use the ICM*compact* are the mains power supply, the AMP IN, and the system ground.

III Operation

III.1 Main Functions

After switching on the ICM*compact*, the LC screen displays the ICM*compact*-logo and software version for about two seconds. The instrument is controlled by the five pushbuttons on the front panel. The individual functions are assigned to each button by the menu fields on the right side of the display. There are several display modes and submenus available.

After power up and display of the ICM*compact* logo, the instrument automatically selects the display mode and submenu that were active when the instrument was last switched off. In order to activate the MAIN menu, you may need to press the EXIT button several times. In this MAIN menu you can select either the METER (MAIN M) or the SCOPE (MAIN S) display mode. If implemented, also the HVM (high voltage meter) is available. Devices with an additional acquisition board (DSO board) for cable fault location have an additionally display called DSO. Figure 7 shows the ICM*compact* in the menu ‘MODE S’. An overview of the key menus can be found in III.2.1.

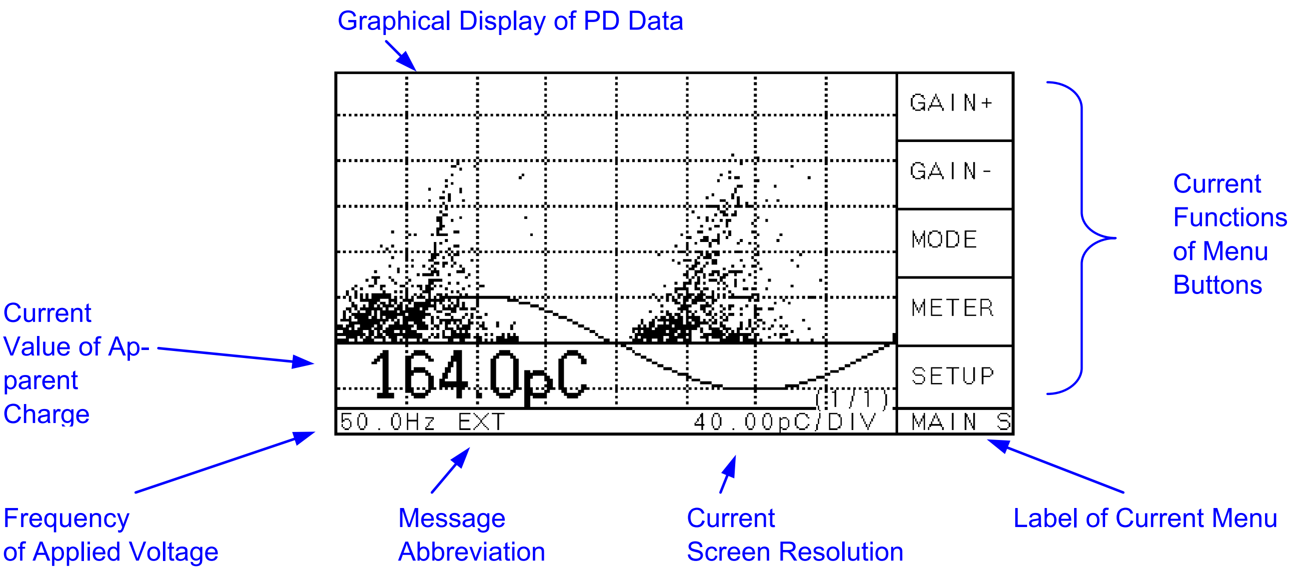


Fig. 7: Parts of the ICM*compact* display

The display of the ICM*compact* consists of graphic elements like the grid, the voltage curve and the PD pattern and additionally text elements like the menu description, the values shown at the lower border and settings written at the upper border. Some conditions are displayed as abbreviations at the lower left side. The following table shows these abbreviations and its meaning.

Abbreviation Meaning

RPA?............ missing preamplifier or damaged cable between preamplifier (i.e. RPA1) and input of the ICM*compact* (AMP IN);

EXT............... external synchronization; the device selects automatically the synchronization source, means that the line voltage will be used if there is no external voltage connected to the SYNC IN at the rear panel. For this, the ESYNC must be enabled.

RPA OFF....... within the submenu MISC the control voltage for the preamplifier can be turned off;

G ....external gating is turned on (see chapter III.5.4)

There are two displays to indicate the captured PD activity. In the Scope display every PD signal is shown on a phase resolved graph. In the Meter display the peak value is shown on an analog meter.

III.1.1 Scope

Within the Scope mode there are 3 ways to display the PD pattern. These types can be selected in the menu MODE and will be explained now.

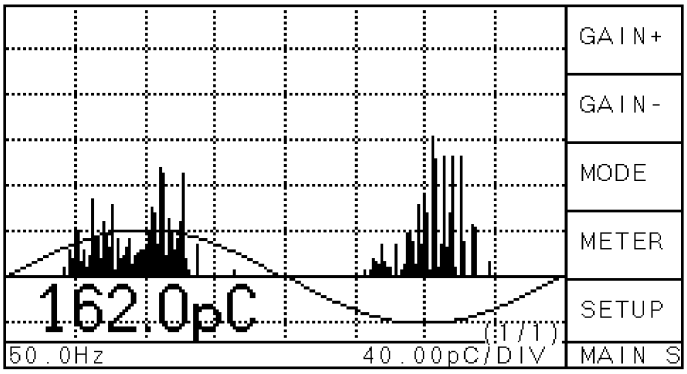


Fig. 8: Scope Display (Norm Mode)

Fig. 8 shows the Scope display with **NORM** mode activated (see menu description for menu MAIN S): Every partial discharge pulse is displayed as a vertical line at the phase angle where it occurs. The length of the line is proportional to the apparent charge amplitude. The display refresh rate of the ICM*compact* is about 0.1s, thus every picture shows the discharge pulses accumulated over the last five cycles of the test voltage (at 50Hz!). The displayed sine wave helps to identify the phase position of the discharge impulses.

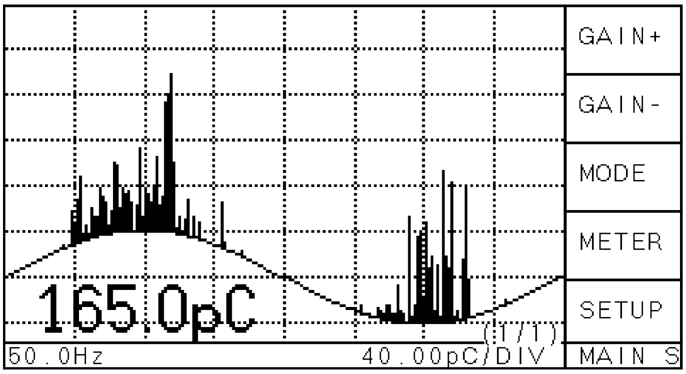


Fig. 9: Scope Display (Sine Mode)

Fig. 9 shows the scope display with **SINE** mode active. The only difference between NORM mode and SINE mode is that in the SINE mode, the impulses are superimposed onto the sine wave.

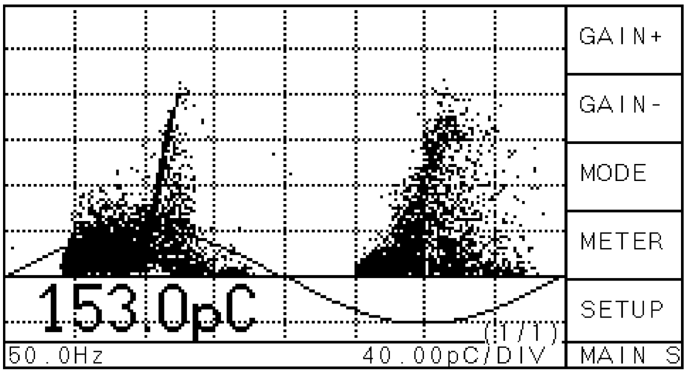


Fig. 10: Scope Display (Hold Mode)

In the **HOLD** mode every partial discharge impulse activates a display pixel at the location according to the pulse magnitude and the phase angle of occurrence. Note that in this case the display is refreshed every 100ms which allows a visualization of the build-up dynamics of a partial discharge pattern (also called PD-Map or phase-amplitude distribution). Changing the gain will reset the this display mode. Despite the fact that the ICM*compact* can only 'count' up to 1 (pixel on/off) and that other technical differences exist between the ICM*compact* and the ICM*system*, the PD maps can be easily recognized and compared to the results obtained by the ICM*system*. The resolution of the ICM*system* is ±128 x 256 x 65536 (16bit) whereby the ICM*compact* is unipolar and has a resolution of 80 x 196 x 1 (amplitude x phase x count depth).

At the bottom of the display the synchronization frequency (left), the scaling of the y-axis in Coulomb per division (right) and the current maximum value of discharge (large letters) is shown. This maximum is calculated from voltage periods during the last refresh cycle. For best results the gain should be set so that this maximum appears in the range of 50-90% of the y-axis total range. In case the PD-values are out of this range no valid Q_p can be shown. This happens if the gain is either too high or too low. In the first case ‘>’ (max. value) and in the second case ‘<’ (min. value) is displayed. The setting of the gain can be adapted manually or automatically by turning on or off the AUTO mode. This option is accessible at the MODE S or MODE M menu.

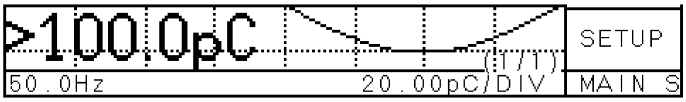


Fig. 11: MAIN menu; charge level out of range

The evaluation of the PD pattern, measured in HOLD mode, enables to determine the kind of fault within the test object. Most PD faults like e.g. isolation damages, voids, surface discharges or floating points will have completely different PD pattern. Typical criteria’s to classify these pattern are:

- phase position of the maximum
- phase position of the starting electron
- the gradient of discharges
- the shape of discharges in the positive and negative half-cycle
- the absolute value of discharge in pC or nC
- short-time or continuous discharges

Some installations make it necessary to correct the phase position of the pattern. For example, measuring on a three phase system without using the external synchronization, where the line synchronization comes from one of the two other phases. In that case a correction of 120° would be necessary. This phase shift can be set at the menu SETUP2 \ LLDSET. Please notice that the correct phase position is absolutely important for proper evaluations of the PD pattern. To avoid the need for applying a phase shift, coupling units that include a voltage divider circuit should be used to provide a signal for external synchronization (e.g. CC20B).

For successful interpretation it is also necessary to get as much information as possible about the test object and its environment. Such information can be, for example, temperature, installation condition, age of the test object, previous faults or weather conditions. It is useful to store typical PD patterns of known faults in an archive. This can be done by using the PC software (see “Standard Software ICM*compact*”, chapter IV.1). This customer specific database will be helpful for later evaluation on other test objects.

III.1.2 Meter

Fig. 12 shows the instrument's display in the MAIN menu and METER mode. The buttons **GAIN+** and **GAIN-** increase or decrease gain resp. amplification factor. Meter scaling automatically tracks the actual calibration and gain factor. The button **SCOPE**, **DSO** or **HVM** activates the next display mode and the button **SETUP** calls the configuration menus. The line beneath the meter, displays the synchronization signal frequency (line voltage, or the external signal at the SYNC IN terminal), the scaling of the meter and the actual peak value of the apparent charge 'Q_P'. MODE calls a submenu for controlling the pointer movement and speed (see Fig. 13).

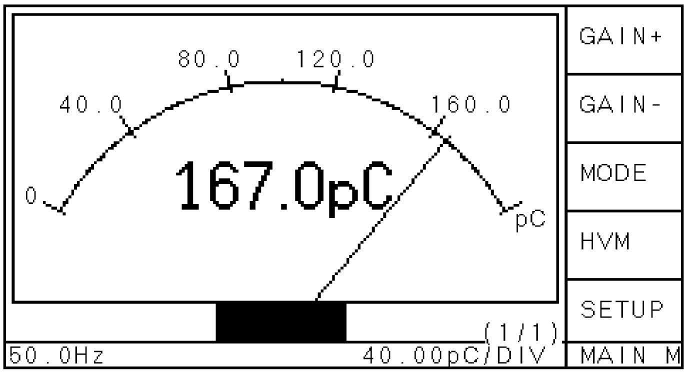


Fig. 12: Meter Display (Main Menu)

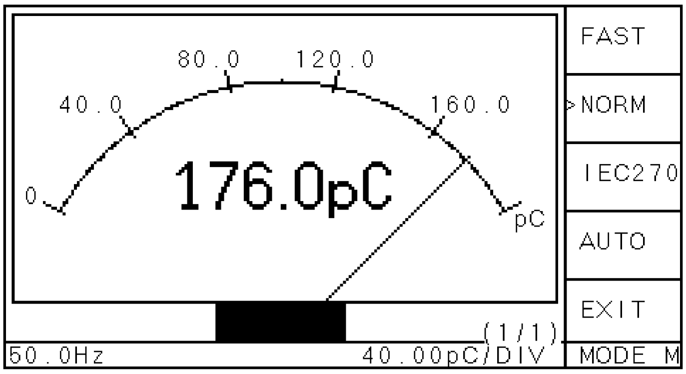


Fig. 13: Meter Display (Mode Menu)

Within the menu MODE M, three different speeds for the pointer can be selected. The chosen option is marked with an arrow ahead. In >**FAST**, the actual peak charge value of an acquisition cycle is displayed; this may lead to unstable readings (i.e. jerky movement of the pointer) when the pulse repetition rate is slower than about $5s^{-1}$. The actual peak value is also displayed in >**NORM** mode, but here the pointer is stabilized: New pulse values are shown immediately yet the pointer falls back slowly until a bigger pulse occurs.

The option >**IEC270** treats the pulses with a weighting curve as mentioned in the actual revision drafts of the IEC 60270. This weighting, which displays rarely occurring pulses only with a fraction of their real amplitude (≥40%), leads to a strong stabilization of the pointer and a reduced reading.

The button **AUTO** activates the auto-range mode in which the gain is automatically adjusted: It is reduced if the display reading continuously exceeds 90% full-range, and increased when the reading remains under 20% of the selected scale. Each change in gain is indicated by a short beep from the built-in loudspeaker. From 1000 pC upwards, the displayed unit changes from [pC] to [nC]. Note: Using sensitive coupling with high charge levels, the system can be over-ranged. In this case we can provide input attenuators (1:10 and 1:100). The **EXIT** button moves back to the MAIN menu.

III.2 Key Menus

All functions described in this chapter base on the current firmware version 2.66. You can find the firmware number either by startup at the info-screen or by selecting the INFO submenu while the instrument is running. Older releases are not completely compatible to the newer ones. Please contact Power Diagnostix to get update possibilities and prices.

Each menu consists of five entries (one for each button) and a name for the menu at the lower right hand side. The background of the menu names are colored in the respective level-color. Each arrow shows the menu the user enters when pushing that button. The EXIT button jumps back to the previous menu (upper level). These ways are not visualized.

III.2.1 Overview

Fig. 14 gives an overview of the whole menus being accessible with the ICM*compact* instruments. The dimmed menus are optional and explained separately in the followed figures. Menus with a gray shadow are optional menus (e.g. HVM, VLF, DSO and gating). They are only accessible if the respective function is included.

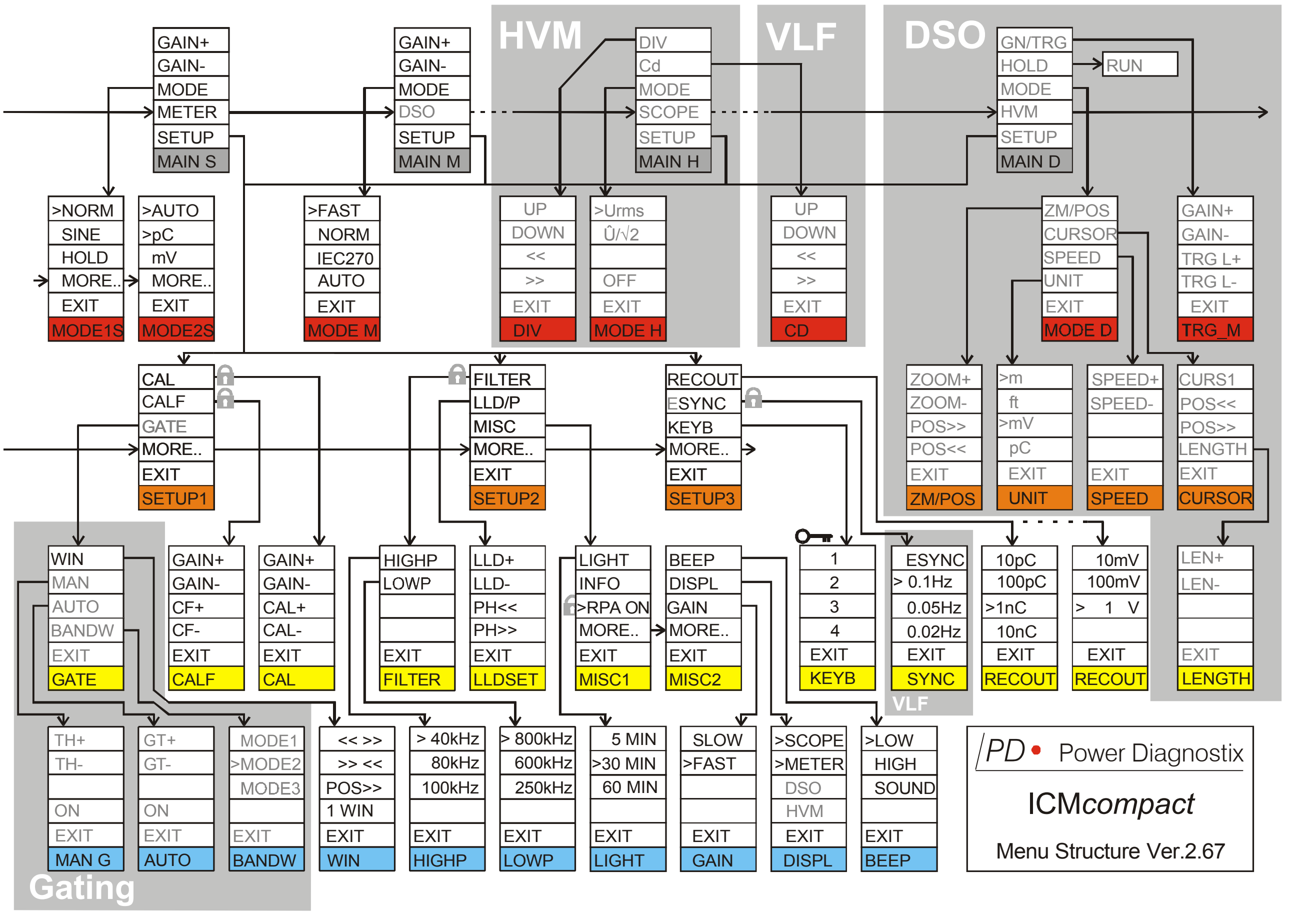


Fig. 14: Whole menu overview

III.2.2 Optional Key Menus

Some text entries can vary, depending on the several setup settings and of the state of the device. All exit buttons will bring you back to the menu one level higher. This path is not signed in. The arrows are showing the way from menu to menu if pushing the appropriate button. At the bottom of each menu its name is written (level-wise colored background).

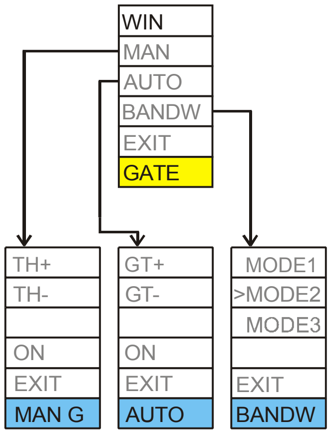


Fig. 15: Optional Menus (Gate)

Fig. 15 shows the optional gating menus. These menus become visible if the device has an external **GATE IN** input channel. In this case, an additional logarithmic preamplifier RPA6 is built in. The noise signal can directly be connected to the GATE IN channel.

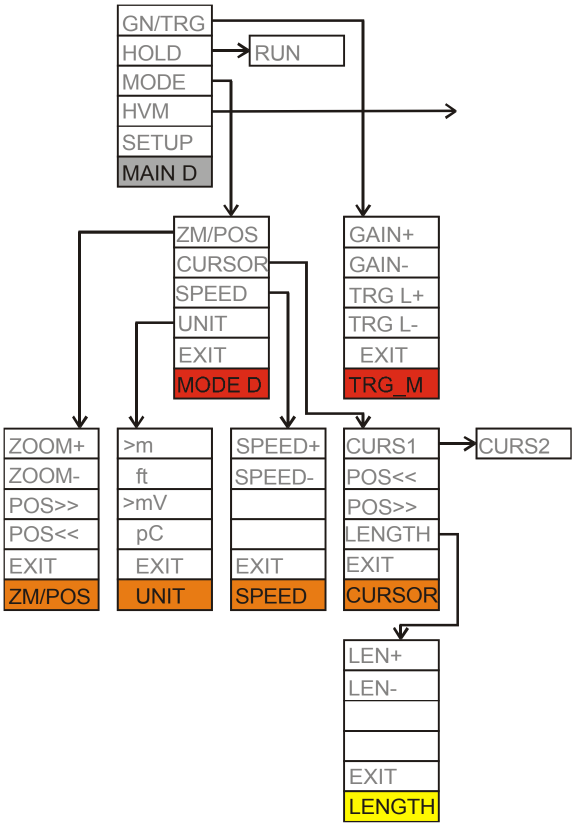


Fig. 16: Optional Menus (DSO extension)

Devices with a DSO acquisition board for cable fault location get the entry **UNIT** within the SETUP4. This option allows to select the display unit for cable fault positions. There will also be an additional menu **MAIN D** for working with the DSO board. This is shown in figure 16.

III.2.3 Key Menus Description

The following list explains step by step all menus coming with standard ICM*compacts'* with firmware releases higher than Ver. 2.40 .

GAIN+
GAIN-
MODE
METER
SETUP
MAIN S

GAIN+ / GAIN-
Sets the amplification of the ICM*compact* signal path up or down. The total amplification is a combination of pre-amplification (external preamplifier, i.e. RPA1) and main-amplification (internal). By selecting the automatic mode (see MODE S), the gain will be adjusted automatically to the current maximum discharge level. The peaks of discharges should be visible at 60 to 90 percent of the total display range. With very high gain settings the noise becomes visible on the screen. If there is no phase dependency of the signals (no discharges), set the noise level to 5% of the total range of the display. This ensures that all newly-appearing discharges will be recognized if their level is higher than the noise at the input.

MODE
Pushing this button changes to the MODE S menu.

METER, DSO or HVM
Depending on the optional DSO acquisition board and the switched on displays (see menu DISPL) this function switches to the next display type.

SETUP
Pushing this button changes to the setup menu. As there are several setup menus, this function enters ever the last setup you've been before.

GAIN+
GAIN-
MODE
DSO
SETUP
MAIN M

GAIN+ / GAIN-
see explanation above;

MODE
Pushing this button changes to the MODE M menu.

METER or DSO
Depending on the optional DSO acquisition board and the switched on displays (see menu DISPL) this function switches to the next display type.

SETUP
Pushing this button changes to the setup menu. As there are several setup menus, this function enters ever in the last setup you've been once before.

Depending on the optional Functions two main menus and their submenus are added. For more information see:

MAIN H	III.3.1 HVM Display
MAIN D	III.3.3 DSO Display

>NORM
SINE
HOLD
MORE..
EXIT
MODE1S

NORM
Setting this option (>) enables the normalized visualization for the phase resolved PD display (SCOPE). The differences between NORM, SINE and HOLD are described in chapter **III**.1.1.

SINE
Setting this option (>) enables the 'sine' visualization for the phase resolved PD display (SCOPE).

HOLD
Setting this option (>) enables the 'hold' visualization for the phase resolved PD display (SCOPE).

MORE..
Pushing this button changes to the menu MODE2S.

EXIT
Pushing this button changes to the MAIN S menu.

>AUTO
>pC
mV
MORE..
EXIT
MODE2S

AUTO
Setting this mode (>) means that the gain will be adjusted automatically to the maximum level of the current PD-pulses.

pC
Setting this mode (>) changes from the acoustic measurement mode ('mV') back to the charge measurement mode.

mV
Setting this option (>) changes the display unit to 'mV' for the acoustic measurement. For a correct calculation of the input voltage it is mandatory to connect the RPA1D preamplifier or to disconnect the RPA supply in the menu MISC1. Within this mode, the CAL and CALF menus are blocked and the FILTER setting are fixed to the frequency range 40 to 800kHz. All these settings are stored before and will be recalled when changing back to the 'pC' display mode.

MORE..
Pushing this button changes to the menu MODE1S.

EXIT
Pushing this button changes to the MAIN S menu

>FAST
NORM
IEC270
AUTO
EXIT
MODE M

FAST
Setting this option enables the fast movement speed of the pointer in the METER display.

NORM
Setting this option enables the normal movement speed of the pointer in the METER display.

IEC270
Setting this option enables IEC60270 mode for updating the pointer in the METER display.

AUTO
Setting this mode (>) means that the gain will be adjusted automatically to the maximum level of the current PD-pulses.

EXIT
Pushing this button changes to the MAIN M menu.

Depending on the optional Functions two mode menus and their submenus are added. For more information see:

MODE H

III.3.1 HVM Display

MODE D

III.3.2 DSO Display

CAL
CALF
GATE
MORE..
EXIT
SETUP1

CAL
Pushing this button changes to the calibration menu CAL.

CALF
Pushing this button changes to the menu CALF. Here the calibration factor can be set directly.

GATE
Pushing this button changes to the menu GATE. The gating function reduces noise coming from e.g. antennas and preprocesses the analog disturbance signal. To use this option the device need to be equipped with an external gating input and the hardware of the device has to be greater than Ver. 2.60. A special logarithmic preamplifier (RPA6) is also needed to amplify the distrubance signal.

MORE
Pushing this button changes to the setup menu SETUP2.

EXIT
Pushing this button changes to the main menu (MAIN S, MAIN M or MAIN D).

FILTER
LLD
MISC
MORE..
EXIT
SETUP2

FILTER
Pushing this button changes to the filter setting menu FILTER.

LLD
Pushing this button changes to the menu LLD to adjust the low level discriminator.

MISC
Pushing this button changes to the menu MISC for miscellaneous settings.

MORE
Pushing this button changes to the setup menu SETUP3.

EXIT
Pushing this button changes to the main menu one level up.

RECOUT
>ESYNC
KEYB
MORE..
EXIT
SETUP3

RECOUT
Pushing this button changes to the menu RECOUT. Here the ratio of charge value to output voltage can be set.

ESYNC
If this button is selected (>) the frequency measurement and synchronization signal is taken from the SYNC IN input, if possible. To manually turn to the line (mains) sync., deselect the button.
With the optional 'VLF', this button is labeled 'SYNC' and changes to the menu SYNC. See also chapter III.3.2. VLF.

KEYB
Pushing this button changes to the menu KEYB. In here crucial menus, which will directly affect the PD measurement settings, can be locked and unlocked. To unlock the keyboard, a sequence of the numbers: 3 4 3 2 must be entered.

MORE
Pushing this button changes to the setup menu SETUP1.

EXIT
Pushing this button changes to the main menu (MAIN S, MAIN M or MAIN D).

GAIN+
GAIN-
CAL+
CAL-
EXIT
CAL

GAIN+/GAIN-
Pushing this button increments/decrements the total gain by one step. The calibration signal should be 50%-90% of the total y-axis range. Changing the gain **does not calibrate** the system. Use the buttons CAL+ or CAL- to recalibrate.

CAL+/CAL-
These buttons can be used to enter the calibration value. Together with the measured peak charge level, the calibration factor is calculated and stored. There is no possibility to make it undo! The value should be set equal to the value shown on the connected pulse generator (e.g. CAL1A). For detailed information's about the calibration procedure see chapter III.4.

EXIT
Pushing this button changes to the setup menu SETUP1.

GAIN+
GAIN-
CF+
CF-
EXIT
CALF

GAIN+/GAIN-
Pushing this button increments/decrements the total gain by one step. This will have no impact on the calibration factor.

CF+/CF-
These buttons can be used to set the calibration factor directly. This function can be used to copy a previously done calibration. For more detailed information's about the calibration procedure see chapter III.4.

EXIT
Pushing this button changes to the setup menu SETUP1.

HIGHP
LOWP
EXIT
FILTER

HIGHP
Pushing this button changes to the menu HIGHP for setting up the lower cut-off frequency.

LOWP
Pushing this button changes to the menu LOWP for setting up the upper cut-off frequency.

EXIT
Pushing this button changes to the setup menu SETUP2.

>40kHz
80kHz
100kHz
EXIT
HIGHP

>40KHZ
Pushing this button sets the lower cut-off frequency to 40kHz.

80KHZ
Pushing this button sets the lower cut-off frequency to 80kHz.

100KHZ
Pushing this button sets the lower cut-off frequency to 100kHz.

EXIT
Pushing this button changes to the setup menu FILTER.

>800kHz
600kHz
250kHz
EXIT
LOWP

>800KHZ
Pushing this button sets the upper cut-off frequency to 800kHz.

600KHZ
Pushing this button sets the upper cut-off frequency to 600kHz.

250KHZ
Pushing this button sets the upper cut-off frequency to 250kHz.

EXIT
Pushing this button changes to the setup menu FILTER.

LLD+
LLD-
PH<<
PH>>
EXIT
LLDSET

LLD+/LLD-
Pushing these buttons increments or decrements the level of the **L**ow **L**evel **D**iscriminator. This value is displayed at the upper right side of the screen in percent. All discharges below that level are deleted and not displayed on the screen.

PH<</PH>>
Pushing these buttons increments or decrements the position of the PD in relation to the zero point of the voltage synchronization line. This value is displayed at the upper left side of the screen in degree.

EXIT
Pushing this button changes to the setup menu SETUP2.

LIGHT
INFO
>RPA ON
MORE..
EXIT
MISC1

LIGHT
Pushing this button changes to the menu LIGHT for setting up the timer for the screen saver.

INFO
Pushing this button changes to the INFO display. This display gives information about the current firmware version, hardware release and the mailing address of Power Diagnostix.

>RPA ON
If this button is selected (>) the power supply for the preamplifier is turned on. Pushing this button until the checkmark is off, turns off the supply to the preamplifier and enables to use the AMP IN terminal directly without preamplifier.

MORE..
Pushing this button will change to MISC2.

EXIT
Pushing this button changes to the setup menu SETUP2.

5 MIN
>30 MIN
60 MIN
EXIT
LIGHT

5 MIN, 30 MIN, 60 MIN
Pushing these buttons sets the automatic screen saver to 5, 30 or 60 minutes. That means, when for about 5, 30 or 60 minutes no button has been pressed, the background lighting of the display will be turned off. The light will be turned on by pressing any button.

EXIT
Pushing this button changes to the setup menu MISC.

EXIT
INFO

EXIT
Pushing this button changes to the setup menu MISC.

The INFO menu contains information about:

- the actual firmware version and release day (SW Version, SW Release)
- the hardware version (HW Version)
- some optional instrument functions
- contact details of Power Diagnostix

BEEP
DISPL
GAIN
MORE..
EXIT
MISC2

BEEP
The sound when pressing one of the five keys can be modified here.

DISPL
Display modes (SCOPE, METER, DSO and HVM) can be deselected in this menu.

GAIN
The speed of the AUTO gain (MODE menu) adjustment can be selected here.

MORE..
Pushing this button will change to MISC1.

EXIT
Pushing this button changes to the setup menu SETUP2.

LOW
HIGH
>SOUND
EXIT
BEEP

LOW, HIGH
Pushing these buttons switches between a higher or lower sound for the buttons.

SOUND
Pushing this button enables (>) or disables the audible indicator for the partial discharge signals.

EXIT
Pushing this button changes to the setup menu MISC.

> SCOPE
> METER
DSO
HVM
EXIT
DISPL

The display modes which are installed in the instrument can be deselected, if they are not currently visible. Modes which are deselected in this menu can not be selected in the MAIN menu and will be skipped. This will increase the handling, especially when the modes are changed frequently.

EXIT
Pushing this button changes to the setup menu MISC2.

> SLOW
FAST
EXIT
GAIN

The AUTO gain is turned on and off in the menu MODE S or MODE M. The sensitivity or speed of the auto-gain can be changed between slow and fast. The SLOW mode is useful if a PD level is quite constant, or if random spikes will disturb a continuous measurement. The FAST mode is useful if rapid changes of the PD level should be captured e.g. when measuring the inception voltage of a specimen. A single PD level which will over range the preamplifier stops the acquisition and the gain is adjusted instantly.

EXIT
Pushing this button changes to the setup menu MISC2.

LOCK
EXIT
KEYB

LOCK
This button allows to lock the keyboard, leaving only the functions available, which will not affect the parameters of the instrument. The locked functions are labeled in the Menu Structure (chapter III.2.1) by: Entering the KEYB menu while being locked, the buttons are labeled 1, 2, 3, 4, EXIT. To unlock the keyboard a sequence of the numbers: 3 4 3 2 must be pressed.

EXIT
Pushing this button changes to the setup menu SETUP3.

ESYNC
0.1 Hz
0.05 Hz
0.02 Hz
EXIT
SYNC

ESYNC
If this button is selected (>) the frequency measurement and synchronization is taken from the SYNC IN input, if possible. To manually turn to the line (mains) sync., deselect the button.

0.1Hz, 0.05Hz, 0.02Hz
For the acquisition with the VLF (very low frequency) option, the external voltage signal from the SYNC IN is mandatory. Selecting one of the three VLF frequencies will deselect the external frequency measurement, and set the sampling time according to the set VLF. The synchronization is done automatically by the SYNC IN input.

EXIT
Pushing this button changes to the setup menu SETUP3.

10pC
>100pC
1nC
10nC
EXIT
RECOUT

10pC,100pC, 1nC, 10nC
Pushing these buttons sets the level of the analog voltage output (RECOUT). The scaling is linear.

Record Output	*button 10pC*	*button 100pC*	*button 1nC*	*button 10nC*
0V	0 pC	0 pC	0 nC	0 nC
5V	5 pC	50pC	0.5 pC	5 nC
10V	≥10 pC	≥100 pC	≥1 nC	≥10 nC

Tab.1: Ranges of the Voltage Output

EXIT
Pushing this button changes to the setup menu SETUP3.

WIN
MAN
AUTO
BANDW
EXIT
GATE

WIN
Pushing this button changes to the menu WIN. The firmware 'window' function makes it possible to blind out pulses with respect to their phase position. At older devices (Firmware <2.00) this function was called GATE.

MAN, AUTO, BANDW
Gating with an external sensor (analog gating) is an optional function. An ICM*compact* with this gating function will have a built in preamplifier (RPA6) and a 'GATE IN' terminal (BNC) on the rear panel. Please also see chapter III.5.4.

<< >>
>> <<
POS>>
1 WIN
EXIT
WIN

<< >>
Pushing this button widens the window(s) for blinding out the pulses on the display. The width of the windows is displayed at upper right side of the screen.

>> <<
Pushing this button scales down the window(s) for blinding out the pulses on the display.

POS>>
Pushing this button changes the position of each window. The phase position value is shown at upper left side of the display.

1 WIN (2 WIN, 3 WIN, OFF)
Selects the number of windows for this software gating. The phase distances using two windows is 180° and 120° for three windows. Press '1 WIN' if you want to get one window for gating. The key always indicates the next option.

III.3 Optional Functions

III.3.1 HVM - High Voltage Meter Display (optional)

Instruments with the option of a HVM display (high voltage meter) are able to calculate and display the voltage waveform connected to the SYNC IN terminal. The scaling of the amplitude and time base is done automatically so that one full waveform is displayed. The calculated values U_{RMS} and $\hat{U}/\sqrt{2}$ can also be shown in the other selected displays (SCOPE, METER, DSO), however this will decrease their refreshing rate. The Software ICM*compact* is able to record these values together with PD level and the date/time. Please also regard the software introduction in chapter IV and the technical data in chapter VII.1.

The displayed waveform has no impact on the calculation of the values shown in the top two rows or other menus. The crest factor (Crest) is calculated by $\frac{\hat{U}}{U_{RMS}} = \frac{peak\_voltage}{effective\_voltage}$ resulting in a factor of 1.41 for not distorted sine waves.

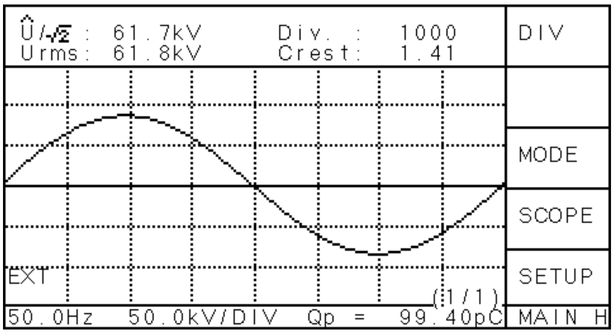


Fig. 17: HVM display showing voltage waveform

To adjust the signal voltage entering (SYNC IN) to the measured voltage the divider factor (DIV.) can be changed by using the buttons DIV+ and DIV-. Holding these buttons will increase the step width.

The voltage frequency and the scaling factor for the displayed waveform are shown in the bottom row together with the peak PD value taken from the AMP IN terminal.

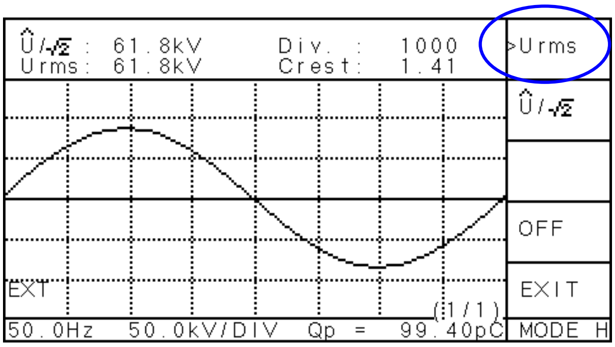


Fig. 18: MODE menu for the HVM mode

To select a value (U_{RMS}, $\hat{U}/\sqrt{2}$) which should be displayed in SCOPE, METER or DSO mode switch to MODE H and select the respective value.

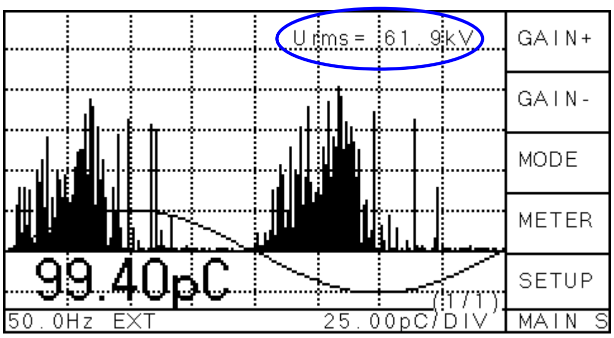


Fig. 19: SCOPE display with U_{RMS} value

DIV
Cd
MODE
SCOPE
SETUP
MAIN H

DIV
Changes to the submenu DIV. Here the divider ratio of the high voltage divider can be set.

Cd
Changes to the submenu Cd. Here the low voltage capacitance can be entered. This menu is only visible if one of the three VLF is selected in the menu SYNC.

MODE
Pushing this button changes to the MODE H menu. (see description below)

SCOPE, DSO or METER
Depending on the optional DSO acquisition board this function switches to the next display type.

SETUP
Pushing this button changes to the last selected SETUP menu.

UP
DOWN
<<
>>
EXIT
CD

This menu is only visible, if one of the three VLF is selected in the menu SYNC.

UP / DOWN
Sets the low voltage capacitance. The selected character (.) can be increased (UP) or decreased (DOWN) by pushing the button.

<< / >>
To select the character which should be changed the cursor (.) can be moved up (<<) or down (>>) in range by this buttons.

UP
DOWN
<<
>>
EXIT
DIV

UP / DOWN
Sets the divider ratio of the high voltage divider. The selected character (.) can be increased (UP) or decreased (DOWN) by pushing the button. The ratio has to be inserted as a factor of 1/x e.g. with a divider factor of DIV = 1000 a maximum measuring range of $100kV_{eff}$ is possible. Since the maximum input Voltage is $100V_{eff}$ or $200V_{peak}$.

<< / >>
To select the character which should be changed the cursor (.) can be moved up (<<) or down (>>) in range by this buttons.

Urms
Û/√2
> OFF
EXIT
MODE H

Urms
Setting this option displays additionally the root-mean-square value of the voltage in the further selected displays (see Fig.19)

Û/Ö2
Setting this option displays the peak value divided by 1.414 in the further selected displays.

OFF
Turns off the additional display of the voltage value in the selected displays (see menu DISPL). This will increase the refreshing cycles in the other displays since the voltage value is not calculated.

III.3.2 VLF - Very Low Frequency

Instruments with the optional VLF acquisition are able to synchronize (trigger) at very low frequencies like 0.1 Hz. Since the synchronization is done by the supplied high voltage, the instrument needs also to have the optional high voltage measurement HVM. An ICM*compact* with the VLF function has an additional submenu 'SYNC' which is accessible in the SETUP3 menu (see chapter III.2). At an ICM*compact* without the VLF function this key is labeled 'ESYNC'.

ESYNC
0.1Hz
0.05Hz
0.02Hz
EXIT
SYNC

ESYNC
If this button is selected (>) the frequency measurement and synchronization with frequencies >10Hz is taken from the SYNC IN input, if possible. To manually turn to the line (mains) sync., deselect the button.

0.1Hz, 0.05Hz, 0.02Hz
Selecting one of these buttons (>) will activate the VLF measurement mode. For the acquisition with this option, an external voltage signal from the VLF system is recommended. Selecting one of the three VLF frequencies will deselect the external frequency measurement. The zero crossing of the voltage signal will be determined by the internal software automatically. The frequency has to be chosen according to the settings at the VLF high voltage source.

III.3.2.1 VLF - Installation, Connection

For partial discharge measurement on a medium voltage cable, the core of the specimen has to be connected to a coupling capacitor C_C (e.g. 1nF). The low voltage side of C_C is then connected to a quadrupole (e.g. CIT4L) suitable to stand the max. current determined by C_C and U_{max}. A broad-band preamplifier should be connected with a short link (coax or BNC-adapter) to the quadrupole. Power Diagnostix offers two preamplifier suitable for this purpose. The RPA1L is designed for laboratory environment and production line and the RPA1H which is suitable for field test. Both preamplifier have a frequency range of 40kHz to 20MHz. The test voltage (VLF high voltage source) is also connected to the specimen core. To minimize noise and unwanted oscillations of the PD signal, the coupling capacitor C_C should be connected as close as possible to the cable under test. Also the earthing connections should be kept short as well. The specimen screen should be connected closely to the quadrupole.

The fault location on cable (TDR) requires a point of reflection, therefore the cable specimen should not be terminated at the far end nor short circuit.

III.3.2.2 VLF – Calibration

Charge Calibration
The calibration for a PD pattern acquisition in the VLF mode can be done in advance, while in the line sync mode (50/60 Hz). This is described in chapter III.4.3. However, it is also possible to calibrate in the VLF mode (e.g. 0.1Hz). Both modes will result in the same calibration factor (CF), but CF is more facile to get in the line sync mode since the calibration signal is more easy to identify.

The calibration of the cable length for the TDR is described in chapter III.3.3.3 (Calibration for the TDR).

Divider Factor Adjustment
The HVM option (**h**igh **v**oltage **m**eter) is mandatory to get the correct phase synchronization with the VLF mode. Therefor, the divider factor (DIV) should also be adjusted. The divider factor can either be read off the coupling unit directly (e.g. CC50/V with DIV=500) or calculated by:

$DIV = \frac{C_C + C_d}{C_C}$ whereas C_C relates to the HV coupling capacitor and C_d to the low voltage capacitor.

For $C_d >> C_C$ applies $DIV \sim C_d / C_C$.

Phase Shift Adjustment
The ICM*compact* will adjust the phase shift (PH) due to the lower frequency automatically. This calculation requires the nominal divider factor and the low voltage capacitor (C_d) of the coupling unit. These values can be set in the menu 'MAIN H' while the synchronization frequency is set to one of the three VLF's (e.g. SETUP3 / SYNC / >0.1 Hz). Usually this values can be found on the coupling capacitor. Using the combined Filter-Coupler unit TCC, the following table shows the relevant values:

Coupler Type:	C_d	Divider factor at 50Hz
TCC25	250nF	250
TCC30	500nF	500
TCC50	500nF	500

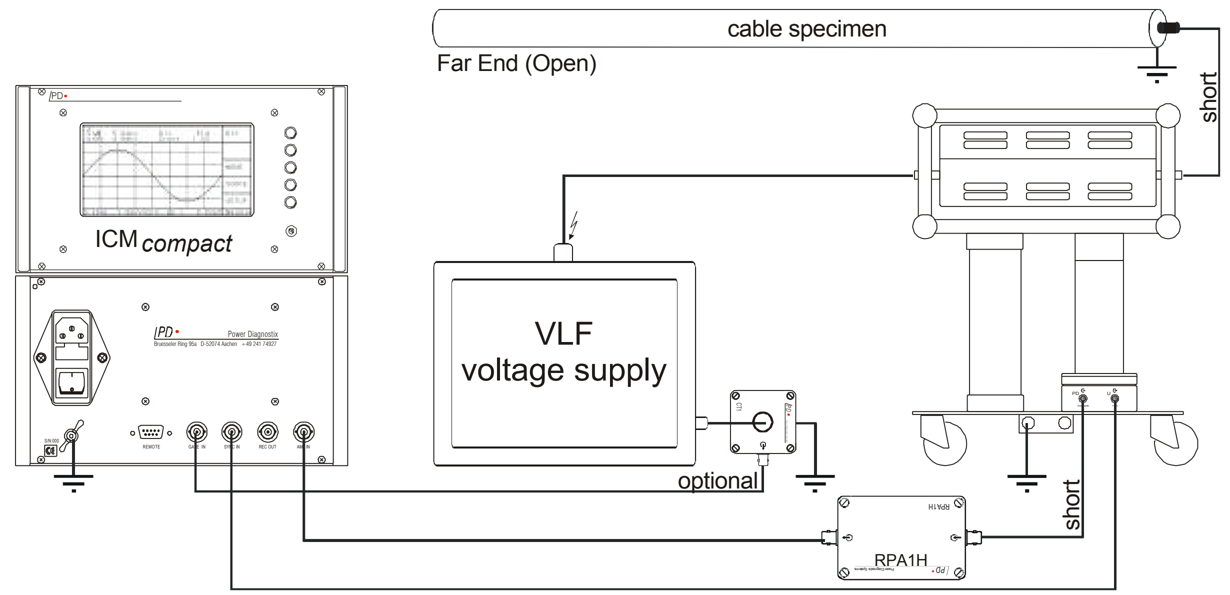


Fig. 20: Example test set-up for a VLF measurement on a HV cable with a TCC filter-coupler-unit

III.3.3 DSO - Digital Storage Oscilloscope (optional) for TDR measurements

Instruments with an optional DSO acquisition board for cable fault location (TDR) are able to process and display PD signals on a time based curve. Single PD pattern can be triggered and recorded with a resolution of 10ns (= 100MSamples/s) and a maximum total display range of 80µs (with Firmware ≤ 2.16: 60µs). This results in a maximum cable length of about 5km (max. measuring time 80µs and pulse velocity of v_C=140m/µs). Since the LCD resolution is limited to 200 pixel the data display is compressed. Using the PC Software extended by 'c' e.g. ICM*compact* 4.55**c** will enable to take full advantage of the high resolution. This software is specialized to locate faults in long cables using the TDR (time domain reflectometry) at the cable terminations. The cable length is limited to about 5km (using max. 80µs measuring time and v_c=140m/µs); it should be at least 10m. Please also regard the software description in chapter IV.2.

III.3.3.1 Measurement principle of TDR with the DSO

The TDR (time domain reflectometry) uses the travel time of pulses. Long high-voltage cable behave as a wave conductor. Therefore, a pulse which is generated e.g. by a discharge, travels to both cable ends. If these do not have the characteristic impedance of the cable (open ends), the pulse will be reflected back to the opposite end. The distance from the fault (pulse source) to the end of the cable is calculated from the time difference (Δt) the two pulses occur at the measured end (coupling unit). Fig. 21 shows an HV cable with a fault. The traveling way of the first three pulses entering the coupling unit are displayed on top.

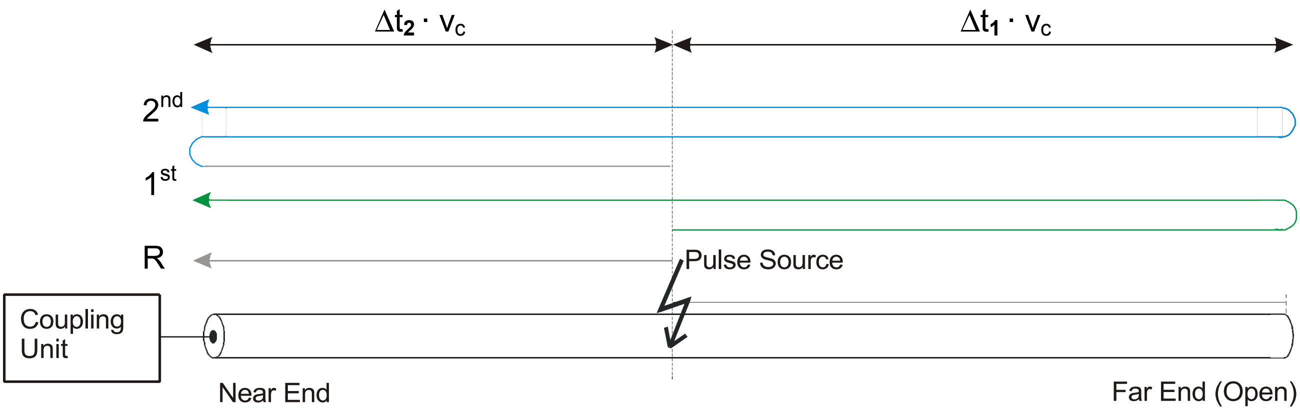


Fig. 21: Propagation of a Pulse in a Cable

Fig. 22 shows the time diagram of the three pulses entering the coupling unit. The reference pulse ('R') travels the direct way to the coupling unit. The 1st reflection has traveled the opposite direction and is reflected at the open end of the cable. Thus resulting in a time delay Δt_1 which indicates the distance of the pulse source to the far end.

The 2nd reflection results from a reflection of the reference pulse at the near end and thereafter at the far end. The time difference between the 1st and 2nd reflection (Δt_2) indicates the distance of the pulse source to the near end.

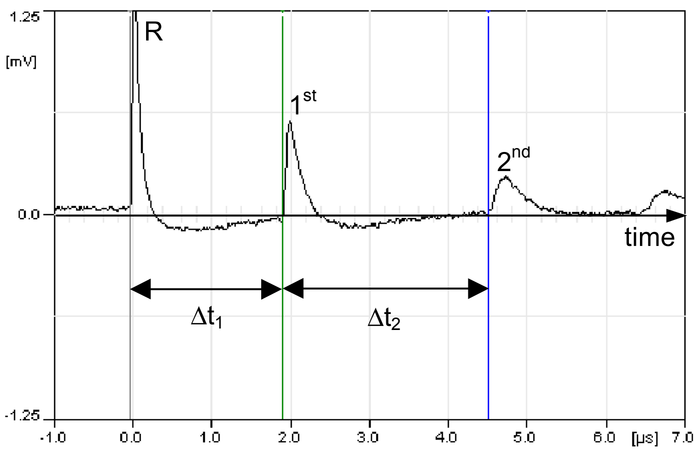


Fig. 22: Time Diagram

III.3.3.2 DSO – Software

The set-up for the acquisition of PD pulses in TDR (single PD pulses are observed) has the same principle than for the PD pattern acquisition. A detailed description of this set-up is already given with the VLF mode in chapter III.3.2.1 VLF Installation. Except, that the external synchronization (SYNC) to the HV is not necessary.

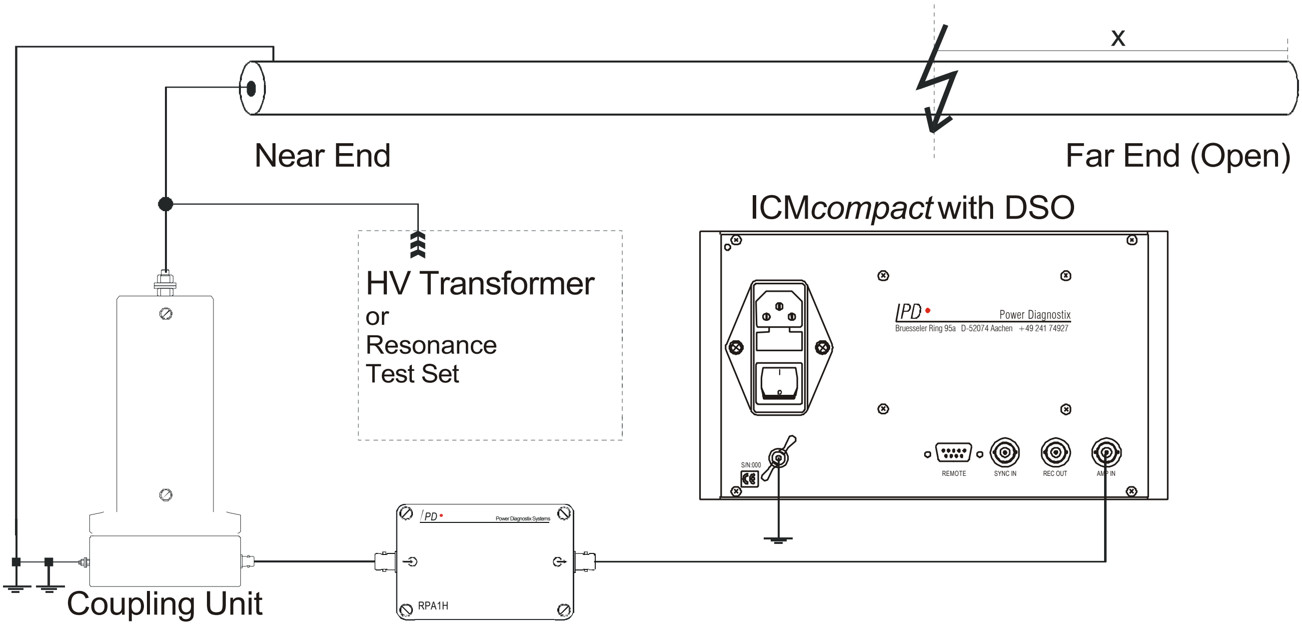
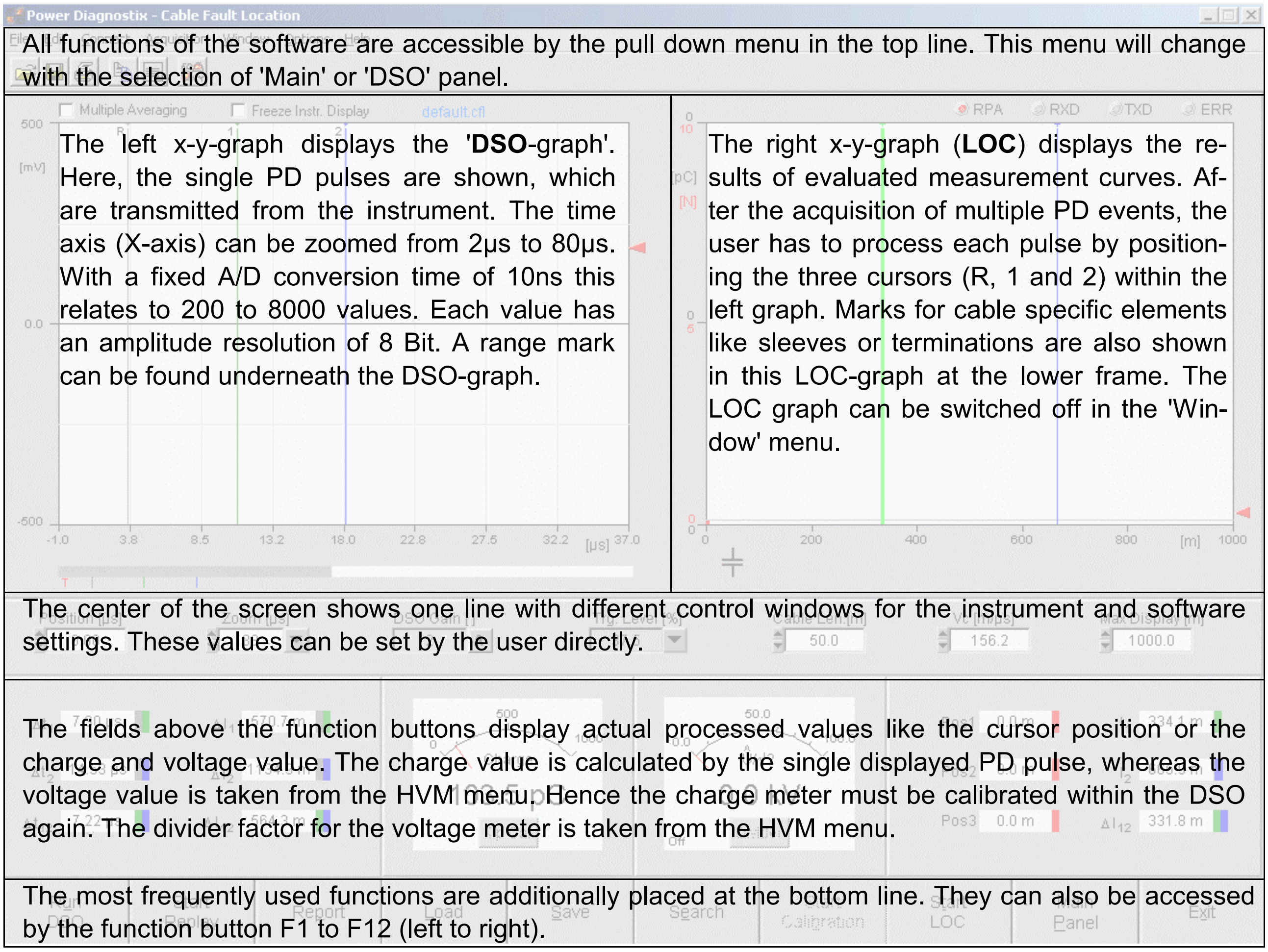


Fig.23: Example test set up for PD location on an HV cable

Although the ICM*compact* can be used as stand alone instrument for cable fault location, the optional software extension greatly simplifies the acquisition and analysis with the DSO board. For this, each instrument has a serial link RS232 labeled 'REMOTE', used to connect to a common PC. To protect the PC, a proper earthing of the instrument is necessary. Additionally, an insulating fiber optical link for the RS232 should be used. There are RS232/FOL converters available which are supplied by the serial-link itself.

With the first online session, the device code of the instrument has to be entered in the software. After a successful initialization of the instrument, the set-up values of the instrument are loaded e.g. range, gain, trigger level, cable length, pulse velocity.

A software with the DSO extension will have a function button (F9) labeled 'DSO Panel'. Pushing this button, changes to the panel for the cable fault location. This panel has two x-y-graphs.



After launching the program and entering the DSO panel, there are two applications possible:

a) Online measurement for cable testing
Pressing the 'Run DSO' button (or F1) will start a continuous online acquisition. This mode displays the acquired curves quickest possible on the software, according to the transmission rate and the set trigger mode.

b) Offline use for data evaluation
To evaluate recorded data, the software should be disconnected with the instrument by pushing the button 'Offline'. This will disable the 'Run DSO' button and change the 'Start Scan' button to 'Start Replay'. Pressing this button opens a further window to select the stored measurement files. One file displays one fault within the cable. All relevant files should be added and are then opened in an extra window. Here two cursors can be set manually to determine the different fault locations. The results of this evaluation is shown in the LOC graph (see above) by red bars, relating to the distance and number of faults.

Position

The displayed range of the x-axis can be shifted by the value 'Position'. Whereas the trigger is always set as zero position of the x-axis and a pre-trigger time of 1µs is fixed by the instrument. However, while in the RUN-mode, the 'Position' will change this pre-trigger time. In the HOLD-mode or when the instrument is offline, the 'Position' will change the displayed range but not the acquired data. 'Position' and 'Zoom' will be adjusted in the HOLD-mode automatically if one value is out of range.

'Position' will shift the x-axis. With the default value of 0µs a pre-trigger time of –1µs is displayed.

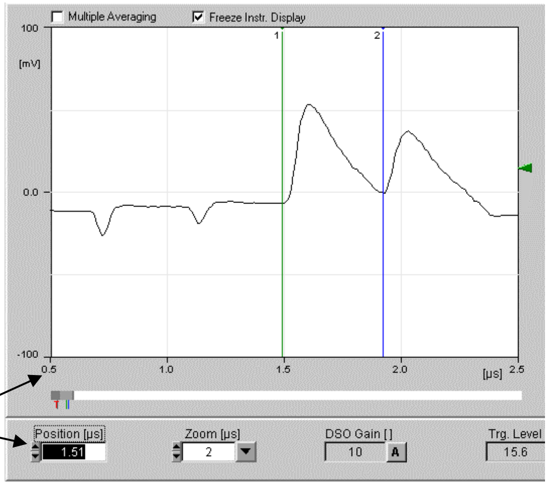


Fig.24: Screenshot of the DSO-graph

Range / Zoom

While in the RUN-mode this value defines the total range in µs. This time base should be kept short to avoid unnecessary data transmission between the instrument and the software.

Example: The ideal range for a cable of 1.4 km length and a known pulse velocity of 165 m/µs is between 18 and 20 µs. (2 x 1400m / 165m/µs = 16.97µs)

Due to the dispersion within the cable, the time range should be set 10-20% higher than calculated. This will ensure to get the complete reflected signal. The value must be a multiple of 2µs and can not exceed 80µs. The white bar underneath the DSO-graph indicates the maximum possible range. The gray bar indicates the actual set range. Within the HOLD-mode, a light gray bar indicates the displayed range of the measured data.

It is also possible to adjust the 'Position' and 'Zoom'/'Range' by the mouse cursor. The mouse arrow will change to a hand for shifting the position or to a double-headed arrow for changing the range/zoom. The colored lines underneath the bar (gray, green and blue) indicate the cursor positions within the DSO-graph. The red 'T' stands for the trigger position and is fixed.

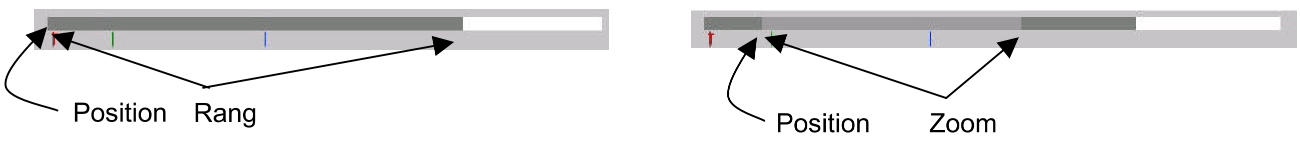


Fig.25: Marking of the range within the RUN-mode and in the HOLD-mode.

The visible part within the HOLD-mode (zoom) can only be part of the acquired data (i.e.: zoom ≤ range). Therefore the range during the measurement should be large enough to be able to zoom during the analysis.

Gain, Trigger Level

The 'Gain' value defines the total amplification of the high frequent signal. The gain can be set between 1 and 80000 (0 – 98dB) in different steps. The trigger level ('Trg.Level') can be set between 0 and 100%. Both values are only accessible in the RUN-mode. Some possible reason for a lack of a repeating signal on the DSO-graph are listed as followed:

- gain level too low; the trigger level is not reached
- trigger level too high; with weak signals, a lower trigger level might be necessary
- no partial discharge activity; even with very high gain only noise signals are triggered-on

A sensible combination of gain and trigger level can be achieved by using a calibrator signal (like described in chapter III.4). The trigger level should be set between 50% and 90% of the calibration signal. The gain should be set, so that the reflection of the cable end is seen clearly and the first pulse is not too much over-ranged. For a later data analysis it is mandatory to capture at least one reflection.

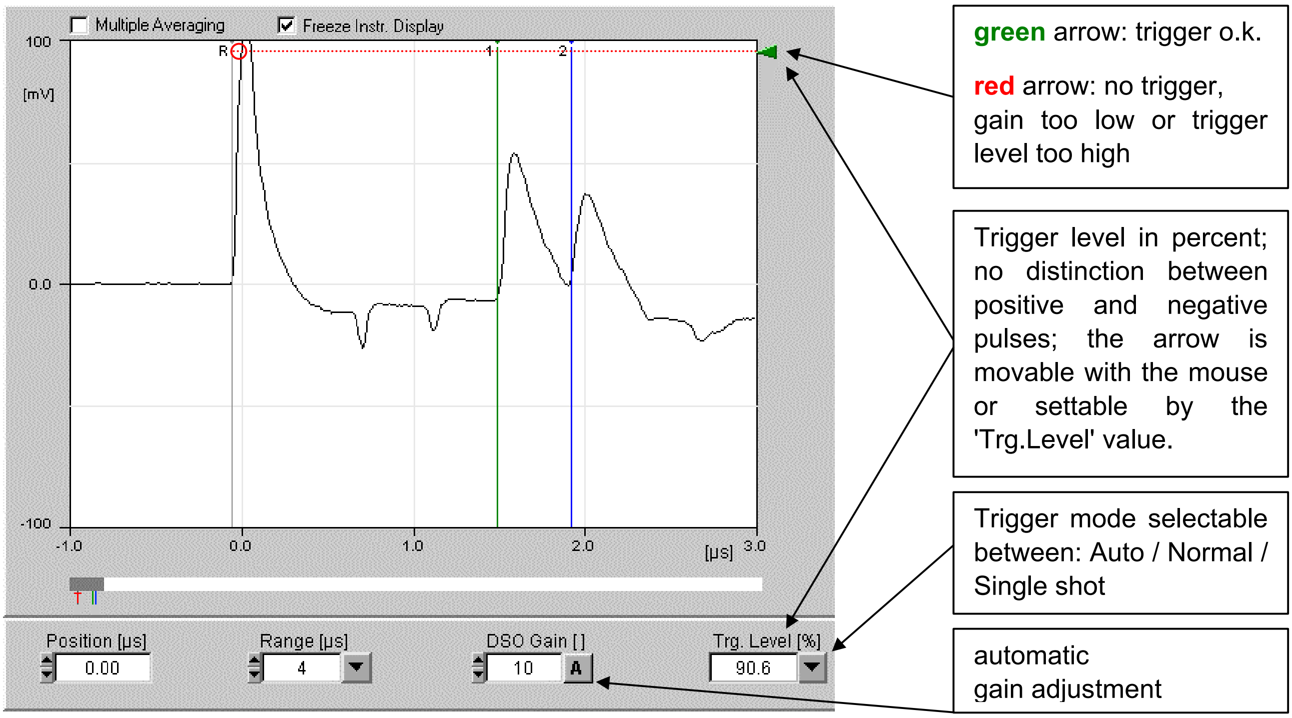


Fig.:26: Screenshot of a DSO-graph

Pushing the button 'A' next to the 'DSO Gain' will automatically adjust the total amplification. For this, the gain is increased stepwise until the first signal reaches the trigger level.
The button next to the 'Trg.Level' ? selects the trigger mode. With the 'Auto' mode, the DSO-graph is up-dated continuously, independently of a trigger event. With the 'Normal' mode, only triggered signals are dis-played. With the 'Single shot' mode, just one trigger event is shown (the first possible) then the software turns to the HOLD-mode.

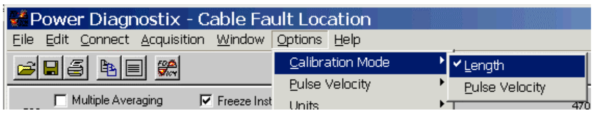
Max. Display

This value limits the indicating range of the x-axis within the LOC-graph. It is possible to choose a value greater than the cable length, however a sensible range is limited by the 'Range' and the pulse velocity. The maximum acquired length can be calculated by:

$$\text{Max.Display}_{max} = \frac{V_C \cdot \text{Range}}{2}$$

Calibration of the cable length (Cable Len.)

The values for the cable length and the pulse velocity can be entered in the fields directly, if known. If only one value is known, the second value can be determined with a calibration measurement.



The selection of the calibrated value is done in the menu: DSO Panel / Options / Calibration Mode / Length.

If the pulse velocity of the cable type is known it can be entered in the related field. The cable length can then be calibrated by injecting an impulse at preferably the near end of the cable.

For this an impulse generator (CAL1A, CAL1B or equivalent) must be connected to the coupling unit. During the calibration the high voltage must be turned off, otherwise the impulse generator might be damaged. To get continuously new curves on the graph, the software must be connected (‘Online’) and put into the ‘RUN’ mode. While injecting a pulse with the calibrator, the gain and the trigger level should be adjusted so that a triggered pulse is seen. The range should be adjusted in the way that the first reflection of the pulse at the cable head is seen clearly.

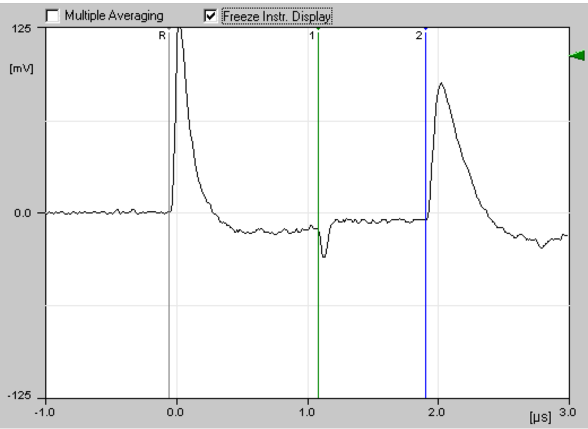


Fig.27: Cursor positioning for length calibration

The gray cursor labeled 'R' can now be placed at the beginning of the first pulse, which is around 0.0µs(see fig.27). The blue cursor labeled '2' should be placed at the beginning of the first pulse reflection from the cable head. The green cursor ('1') is not used during the calibration. Now the 'Start Calibration' button (or F7) should be pressed. After selecting a suitable folder and number of files to be recorded (usually one is sufficient), the record starts. Each triggered curve is saved in a separate *.dso file, and the position of the blue cursor (‘2’) within this graph is transferred to the LOC graph (right) and summed up in the red bars. Finally the calibration files can be saved together with further information about the specimen (Report) in a *.cfl file. After the acquisition has finished, the cable length is automatically calculated by the entered velocity (Vc) and the tallest red bar.

Calibration of the pulse velocity (Vc)

If the cable length is known, the pulse velocity can be calibrated. For this a calibration as described above should be done. With a double click of the left mouse button at the position of the red bar a new window will pop up. By entering the precise cable length into this window, the pulse velocity will be calculated automatically.

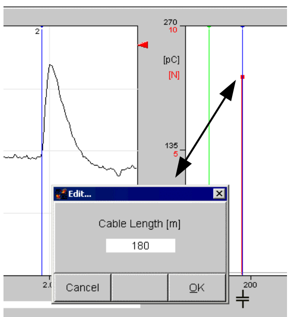
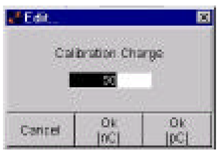


Fig.28: Vc calibration

Calibration of the charge value (Qp Cal)



The button 'Qp Cal' within the charge meter allows to calibrate the current DSO curve. The entered PD value will be assigned to the area underneath the triggered pulse. Thus, this charge value represents the single displayed curve, whereas the charge value shown in the Main panel represents the peak charge value since the last data refresh.

Description of the Functions

The function keys at the bottom of the window offer the major functions needed for a cable fault location. In the following these are described in detail as well as the different conditions of the program. Active function keys are marked with dark gray. The keys are labeled with the function that will start when pressed. They are **not** showing the current state of the program. E.g if the program is in the HOLD-mode, the first key (F1) is labeled RUN. By pressing this button, the program turns to the run-mode (starts the acquisition) and the button is labeled HOLD. Without a serial connection to an instrument, the program can not be turned into the RUN-mode.

Fig.29: Offline (instrument not connected)

Fig.30: Offline, Replay function started

Fig.31: Online, in RUN-mode

Fig.32: Online, in RUN-mode with Scan- and Calibration function started

Run / Hold DSO (F1, Ctrl+u or Ctrl+o)

The program has two states for the DSO-graph. With the first state ‘RUN’ the program takes continuously data from the instrument. Depending on the trigger mode, the DSO-graph is updated continuously as well. Three trigger modes can be selected by pushing the arrow ? next to the 'Trig. Level' field:

- With the **AUTO** mode selected, each transmitted curve is displayed.
- With the **NORM** mode selected, only triggered curves are displayed.
- With the **SINGLE** mode selected, only the first triggered curve is displayed, then the program turns to the HOLD mode.

The HOLD mode always displays the last triggered curve or last file which was loaded. The program must be in the HOLD-mode to start a replay of recorded data.

Start/Stop Replay, Start/Stop Scan (F2, Ctrl+A)

The second function key (F2) changes its function depending on the program status. Here are one of the most important functions for the data acquisition (SCAN) and evaluation (REPLAY). Only if the software has an online connection to the instrument, the SCAN-function can be used. While ‘offline’, the REPLAY-function is available. Both functions are closely linked.

The SCAN-function saves measurement data in different files. These files will have the extension ‘*.dso’ and can be loaded and processed later, while the software is offline. The dso-files contain only raw data to minimize the memory requirements.

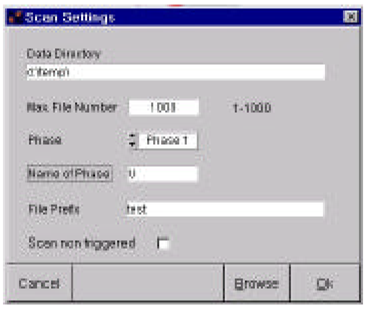


Fig.33: Settings entry window

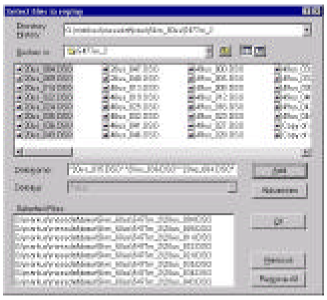


Fig.34: File selection window

After the SCAN-function is started, a window like the one shown in fig.33 pops up. The entry ‘Data Directory’ defines the destination folder where all recorded files are stored. It can either be entered manually, or chosen from the existing folder structure by the button ‘Browse’. The entry ‘File Prefix’ defines the name of the data-files. The later file-name is put together from the entry in 'File Prefix', the chosen 'Phase' name, a consecutive number, and the extension '.dso'. The quantity of files recorded can be set in the 'Max. File Number' field. A value between 1 and 1000 can be chosen. The option 'Scan non triggered' allows to save also files which are not generated by a trigger event of the pulse. This option might be helpful, if heavily distorted signals are present and a firm triggering to dominant PD pulses is not possible. With this option, randomly taken data are recorded and analyzed later. For this, the 'range' should be long enough to search for PD pulses and their reflections within the data stream. The acquisition is started by the 'Ok' button and stopped by the 'Cancel' button or if the number of files is complete.

The Replay-function can only be started if the instrument is offline. It will open a sub-window in which the scanned data-files can be selected. It must be pointed out that only data with the same time-range should be selected at once.

After confirming the selection with the OK button, a new sub-window opens. Here the recorded graphs are shown one after the other together with two cursors. The path and filename of the current displayed graph is shown in the upper right hand corner. Now the user can place the gray cursor at the base of the trigger-pulse (around 0µs). The red cursor should be placed at the base of the first reflection of that pulse. **'Select'** will take this cursor interpretation, save the cursor positions, and put one red bar into the LOC-graph of the main window. If there is already a red bar at that position, it will increase the length (number) of this bar. **'Select All'** will take the saved cursor positions of all selected files and add the results to the LOC-graph in the main window. This should only be done, if an interpretation of the graphs was already done and saved in the *.dso files. **'Skip'** will ignore the displayed graph and move to the next selected one without action. **'Back'** moves one selected graph back and deletes the last result in the LOC-graph, e.g. to correct a misinterpretation. **'Delete File'** will remove the displayed file from the disc. With **'Save File As'**, the current file can be copied and renamed. **'Cancel'** stops the whole replay function.

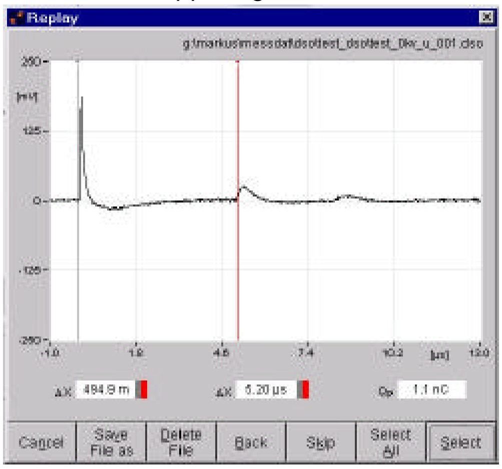


Fig.35: Replay window for data analysis

Each selected file is automatically counted in the LOC-graph. The position of the red cursor determines the marking of a defect within the LOC-graph.

Report (F3, Ctrl+R)

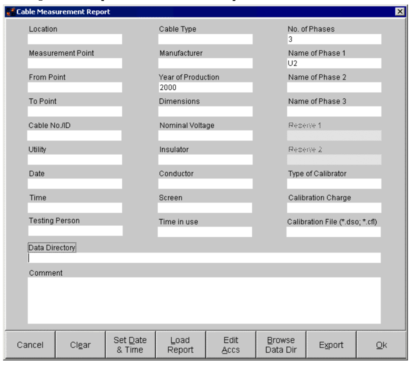


Fig.36: Report entry window

This report is saved together with each ***.CFL** file created by the 'Save' (F5) function. It allows the user to add comments and further information to the measurement data. The report will be printed and exported to text-files. **'Set Date&Time'** places the current PC time into the related entries. **'Load Report'** allows to change the *.dso graph which is saved together with the report data. **'Edit Accs'** (Edit Accessories) opens a further sub-window where the 'List of Accessories' can be changed. They are also saved with the CFL-file. With the **'Browse Data Dir'** the destination of the CFL file can be changed. **'Export'** will save the report data as a standard ASCII file (*.txt).

Load (F4, Ctrl+L)
In the offline-mode saved files can be loaded and displayed. Both types can be loaded, the pure scanned graphs (*.dso) and the project files (*.cfl). The project files contain the last displayed DSO graph together with the setup information of the instrument, the report entries, as well as the fault location within the LOC graph.

Save (F5, Ctrl+S)
Saves the currently displayed data in an *.cfl file.

Search / Offline (F6, Ctrl+E)
This function connects or disconnects the link to an ICM*compact* instrument. During the connection all selected ports are scanned for possible instruments. This are by default the ports COM1 and COM2, however up to 16 COM ports as well as GPIB and virtual LAN ports can be selected. The selection can be changed in the MAIN Panel / Options / Interface Settings / RS232 or GPIB or LAN. During the program launch and when changing the panel, the search function is activated automatically.

Start Calibration (F7, Ctrl+B)
This function calibrates either the cable length or the pulse velocity. A detailed description is given on page 37. The calibration of the charge magnitude is done by the ‘Qp Cal’ button within the ‘Charge’ meter. Whereas the voltage magnitude can be adjusted by the 'Divider' button within the voltmeter.

Start LOC (F8, Ctrl+T)
This function starts the fault-location (LOC / Location). To activate the automatic mode, the option 'Options / LOC Graph / Calculations / Auto' must be selected. The processing of the measurements is based on the correlation frequency-distribution and the results are shown in the right-hand graph (LOC-graph). Each triggered curve which can be seen in the DSO-graph is put into correlation with a reference pulse. This reference pulse was prior artificially 'aged' i.e. the dispersion of the cable is already taken into account. After the correlation, the maxima are put together in a three-dimensional field. With an increasing measuring time, the reflection position will show accumulation points. The sum of this accumulation points within on segment of the x-axis are pictured by red vertical bars also called projections within the LOC-graph. But only points which exceed the set level are taken into account. This level can be seen as red arrow next to the LOC-graph.

The most frequent maxima (also called peak distribution) are indicated as faulty positions underneath the LOC-graph next to 'Pos1'... 3. Via the menu 'Options / LOC Graph' different results can be shown or disabled. Two cursor can here be activated to 'measure' distances. The results of the cursor distances are shown underneath the LOC-graph. Also the sensitivity for the projections (red bars) can be adjusted.

The LOC function is automatically started with the replay of saved measurements. It must be pointed out, that the counting within the LOC-graph starts from the far end. The display range for the x-axis ('Max.Display') should always be larger than the cable length, otherwise faults can be overlooked.

Note: The automatic analysis of the curves (correlative peak distribution) should not be the only criterion for the fault location. To verify the results the original DSO curves, the installation plan and the impact of disturbances should be taken into account!

If the software is offline, the 'Start LOC' button will start the manual fault location as does the button 'Start Replay'.

Main Panel (F9, Ctrl+P)
This button changes the instrument back to the PD mode, the software will also change it's acquisition mode. One brief interruption during this switch is usual.

Exit (F10, Ctrl+X)
The program is terminated by the EXIT button.

Menu Options
Some additional functions are accessible via the menu block at the top of the program window. In the following those functions of the menu block are described, which are not accessible within the main user interface.

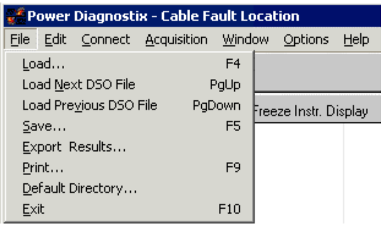


Fig. 37: Pull down menu 'File'

With the buttons '**PgUp**' and '**PgDown**', the next respectively previous DSO file can be loaded from the current folder. The program has to be in the offline mode. A brief message will give a warning, if no DSO file can be found in the selected folder.

The function '**Export Results**' will put the calculated fault positions, shown in the LOC graph, into an ASCII text file. The 'Report' data are also added.

With the function '**Default Directory**', a folder can be selected which is automatically opened with the 'Load' or 'Save' function.

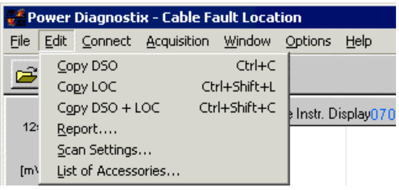


Fig. 38: Pull down menu 'Edit'

The menu 'Edit' offers functions like '**Copy** DSO', 'Copy LOC' and 'Copy DSO+LOC' to put one or both graphs into the Windows clipboard. From here, they can easily be exported into other programs by 'Ctrl+V'.

The basic settings for a scan can be changed without starting a scan and even without being online by the '**Scan Settings**' menu.

The '**List of Accessories**' is a helpful tool to add information into the LOC-graph. In here, cable accessories like sleeves, junctions or terminations can be added and will be shown as small icons within the LOC-graph.

The pull down menu ' Acquisition' repeats functions, which are already described on the previous pages.

Fig.39: Pull down menu 'Window'

The LOC-graph on the right hand side can be disabled to enlarge the DSO-graph. This is helpful, especially with long cable specimen to get a better resolution for the positioning of the measurement cursor. By default the 'DSO+LOC' is set to see both graphs.

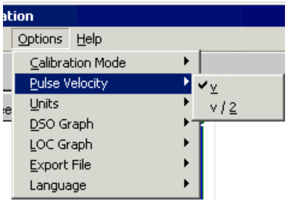


Fig. 40: 'Options \ Pulse Velocity'

The 'Pulse Velocity' (propagation speed of electrical signals within the cable) can be displayed as absolute value '**v**' or as halved value '**v/2**'.

The units in which length and speed are shown, can be altered between the '**SI-System**' (MKS = meter, kilo, second) and the 'fps-System' (= feet, pounds, second).

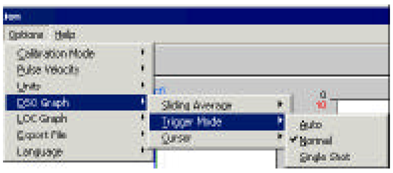


Fig.41: 'Options \ DSO Graph'

If the '**Sliding Average**' is 'on', multiple acquisitions of the DSO graph are averaged before they are displayed. For this it is necessary to trigger always to the same fault signal.

The '**Trigger Mode**' allows to select 'Auto', 'Normal' and 'Single Shot'. This mode affects the repetition of the acquired graphs.

The cursor within the DSO-graph can be hidden '**off**' or shown '**on**', so can the cursor within the LOC-graph.

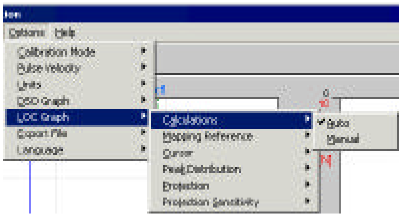


Fig.42: 'Options \ LOC Graph'

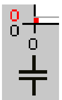


Fig.43: Coupling capacitor symbol

Most of the settings refer to the LOC-graph.
The analysis of the LOC-graphs '**Calculation Mode**' can be done **automatically** or **manually**. However, if the graph is more complex it is recommended to do a manual analysis to avoid misinterpretations.

By the physical properties of TDR, the cable measurement always starts from the far end i.e. the opposite end with no sensor. Therefore the default display also measures and shows the results from the '**Far End**'. However, the '**Mapping Reference'** can be changed to start with the 'Near end'. This will be indicated by a capacitor symbol as sensor at the zero position of the cable.

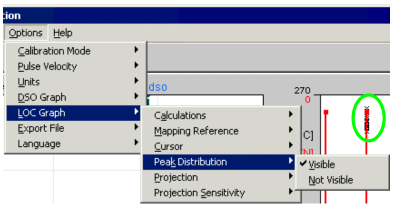


Fig. 44: 'Options \ LOC Graph'

The '**Peak Distribution**' shows each measurement result by a small 'x'. This function can be enabled ('Visible') or disabled ('Not Visible').
The '**Projections**' (red bars) indicate the quantity of measured faults at one cable position. They also can be shown ('on') or hidden ('off').
The '**Projection Sensitivity**' defines kind of summation. Depending on the setting 'High', 'Medium' or 'Low', the segments in which the peak distribution is summed up as one red bar can be changed. A 'High' projection sensitivity results in small segments which will increase the total number of red bars and decrease the number of counts.

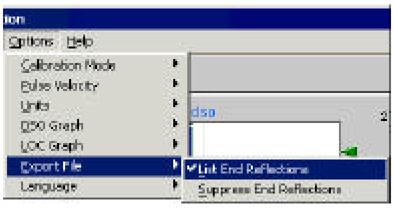


Fig. 45: 'Options \ Export File'

When exporting the data from the LOC-graph and the Report entries, the selection '**Export File**' allows to suppress pulses from the cable ends ('**Suppress End Reflections**'). This is helpful, if the user is only interested in faults within the cable and doesn't want to see pulses from the cable terminations.

With '**Language**' the inscription of the software as well as in the report files can be changed between English, German and Spanish. Some shortcuts used with 'ALT+...' will change also. Generally the letter which is underlined on a function button can be used as a shortcut. Outside the pull down menu the 'ALT' button has to be pressed while using the shortcut letter. Within the pull down menu the underlined letter can be pressed directly to jump into the specific function.

III.3.3.3 Calibration for the TDR

Before raising the voltage on a cable for the actual PD location, a TDR snapshot is done for calibrating the PD magnitude. This can also provide information on the length of the cable, locations of joints, condition of the neutral wire, and the level of sensitivity you can expect to obtain with PD measurements. For the calibration followed calibrators are recommended to use:

XLPE (Polymeric Cable) ⇒ **CAL1B** (0.1 to 10 nC) or **CAL1D** (10 to 1000pC)
Mass Impregnated Cable ⇒ **CAL1B** (0.1 to 10 nC) or **CAL1E** (1 to 50pC)
Laboratory Measurements ⇒ **CAL1A** (1 to 100 pC)
A list of all available calibrators can be found in chapter III.4.1.

Caution: For calibration the system has to be de-energized.

With the cable de-energized the calibrator has to be connected to the conductor and neutral by two short leads at the near end of the cable (see figure 46). After increasing the gain of the ICM*compact*, the magnitude of the calibration pulse should be increased until the pulse reflections are visible. Either the pulse velocity (Vc) of the cable or the cable length can be determined by the instrument or the software.

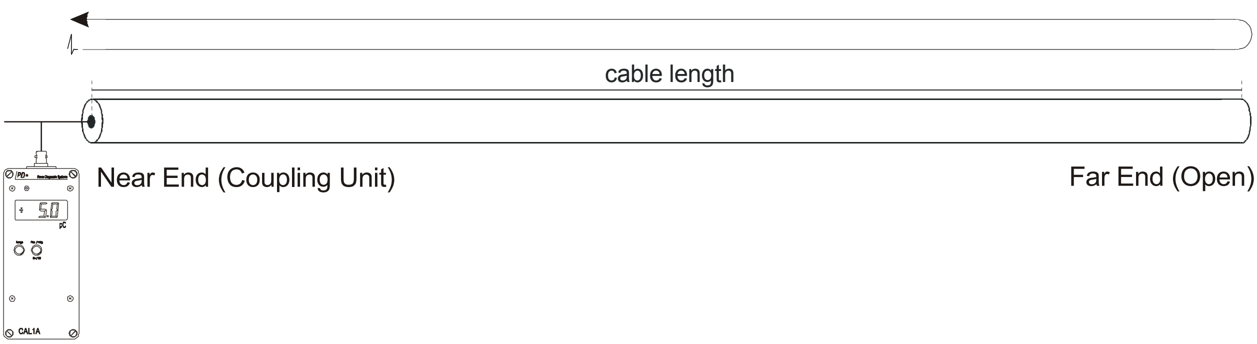
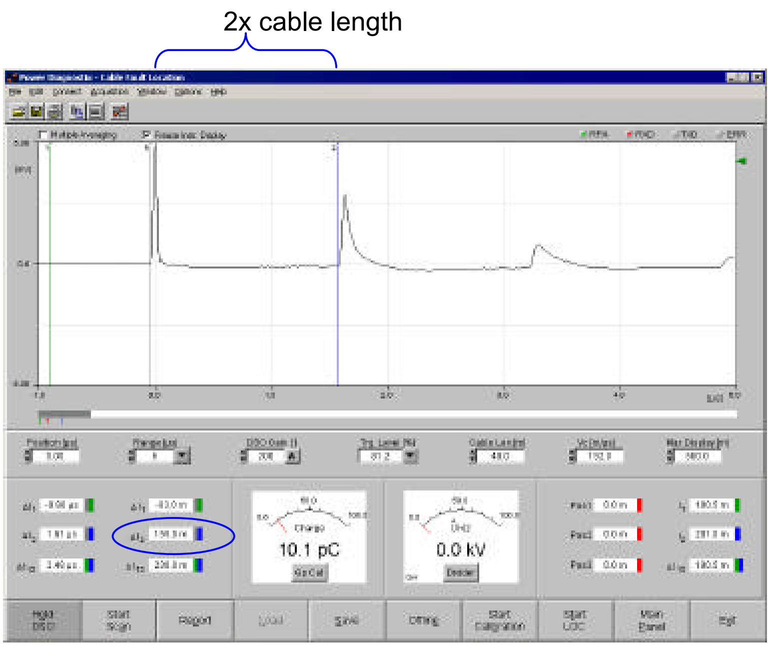


Fig.46: Connection of the Calibrator



In the example given in figure 47 the pulse velocity (v_C = 192 m/µs) was inserted. After the two cursors were positioned, the cable length (ΔX2 = 155 m) was calculated.

It is also possible to calculate the pulse velocity if the cable length is know.

Fig. 47: Time Diagram taken from the ICM*compact* software

Measurement example with the TDR

The next figures show measurement examples of a cable having a cable joint. In figure 49 a joint was detected at 95,7m measured from the far end.

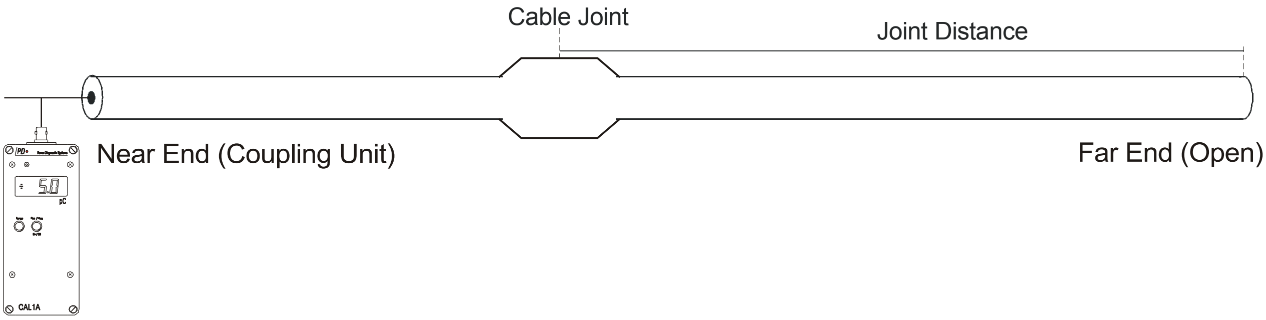


Fig.48: Joint location

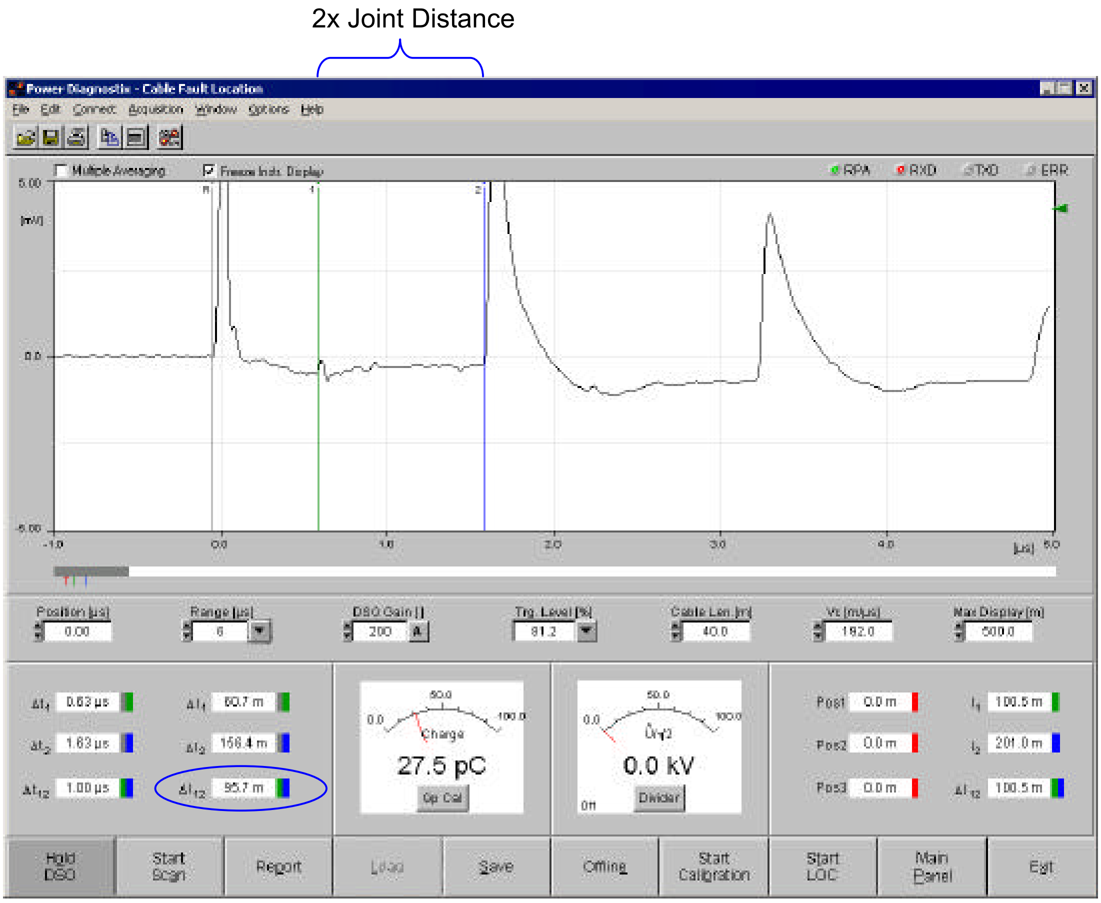


Fig. 49: Joint location on a cable

Once the cable length has been specified and the joints are located, the cable can be energized. Figure 51 shows a measurement with one fault at 185,3m taken from the far end. Consider that the distance is now taken between the 1st and 2nd cursors and not between the 2nd and 3rd, like at the calibration.

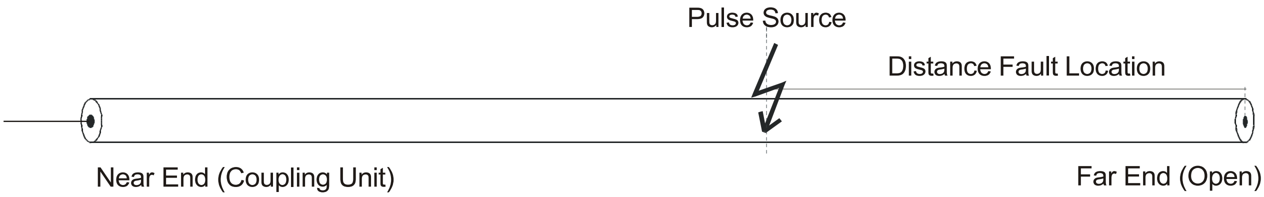


Fig. 50: PD location on a cable

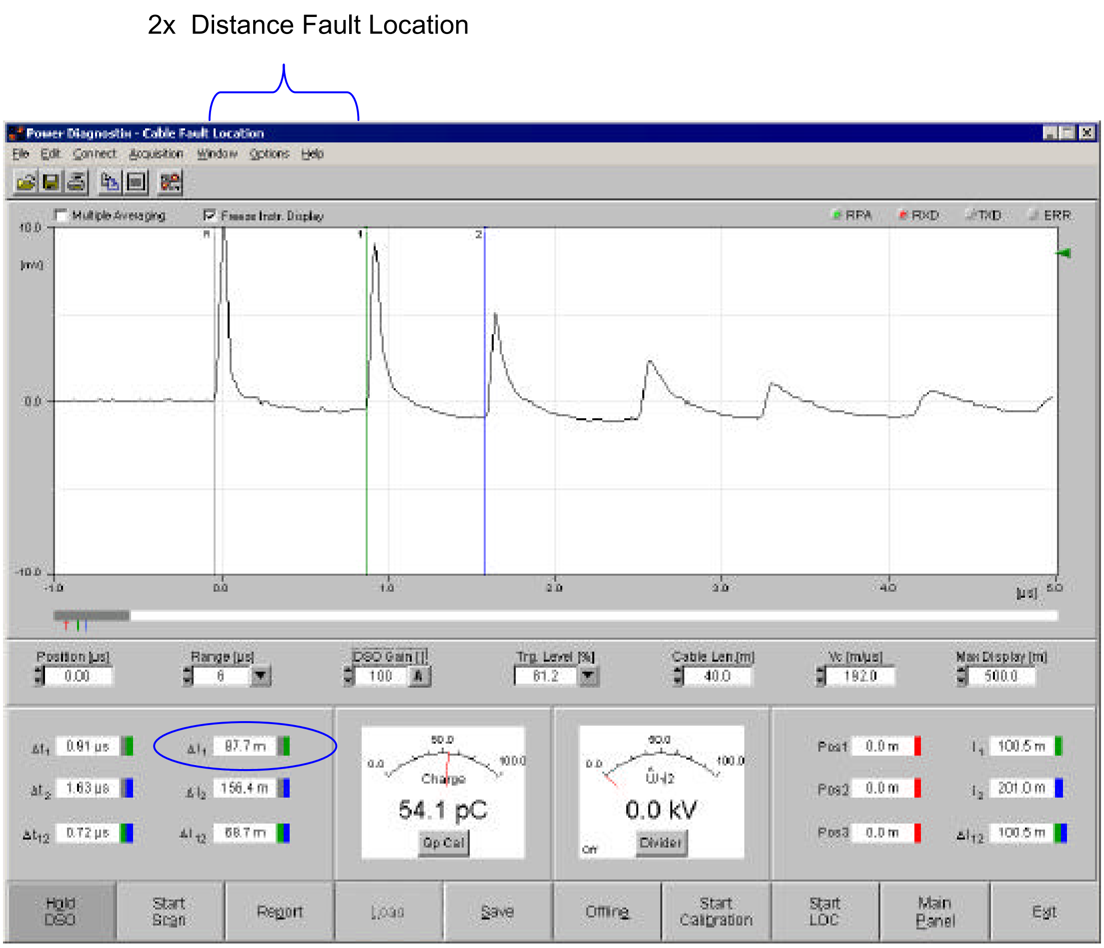


Fig. 51: Time Diagram of a PD location

III.3.3.4 Functions for the DSO

To get a proper PD pulse, the gain and trigger values have to be set correctly. These factors are **independent** from the calibration factor described in chapter III.4.3. Figure 52 shows an example of a triggered PD pulse with all its echoes taken from a HV test cable. Setting the trigger level and the amplification can be done in the submenu TRG_M, which is found under the main menu MAIN_D. The Gain has to be increase until a trigger event occurs. Pushing one of the two gain buttons (**GAIN+** / **GAIN-**) will display the absolute gain value at the upper right border of the screen for a short moment (Provided a preamplifier is connected). The Gain can be set from 2 to 80000 in 17 steps. With a very high amplification the trigger level reaches the range of the input noise. The trigger level should be set between 50 and 90 percent of the y-axis range. Pushing the trigger buttons (**TRG+/TRG-**) will display the trigger level as a horizontal line for about 3 seconds. The trigger makes no difference between positive or negative pulses, it is an absolute value. For better evaluation it is necessary to see the area in front of the trigger pulse. This pretrigger is fixed to 1µs (100 samples).

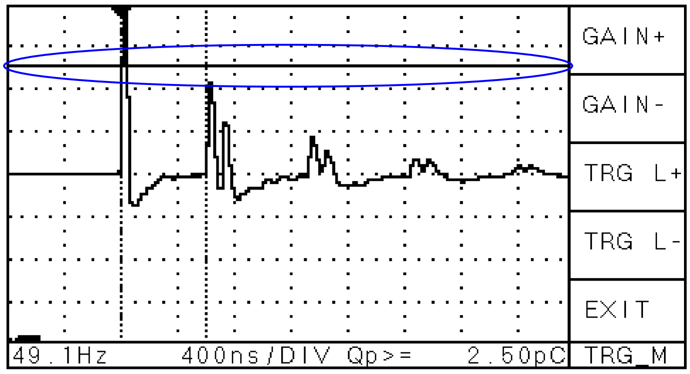


Fig. 52: Set Trigger Level

For the cable fault location it is mandatory to use a preamplifier with a high bandwidth. Power Diagnostix offers for this application the preamplifier RPA1L or RPA1H (40kHz-20MHz). The higher bandwidth is necessary to measure the pulses and its reflections running over the HV cable without attenuation and distortion of the preamplifier. The time-distance of the pulses is the decisive criteria for the location. Parameters like pulse velocity or cable length will be needed to calculate precisely the fault position within the cable. These settings can be changed with the menus **SPEED** or **LENGTH**. The user can select between the units meter or feet within the menu **UNIT**. This submenu can be entered via the setup menu SETUP3.

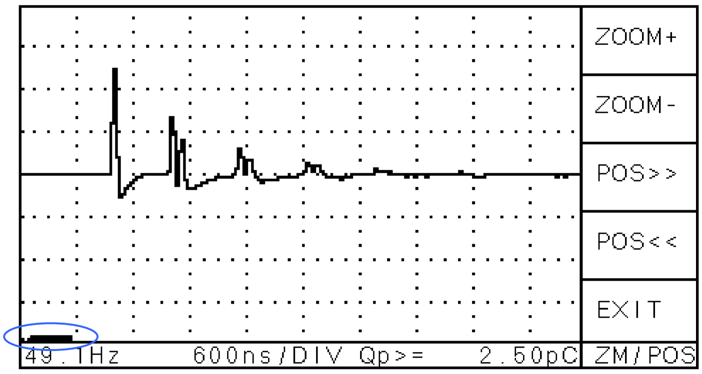


Fig.53: Indicator for the Displayed Area

After setting the correct trigger and gain, the PD pulse becomes visible. The triggered pulse and two reflections should be displayed before going on with further evaluations. Adjust the zoom if less or more reflections are visible.

After a single PD pulse is captured and hold (menu MAIN D, **HOLD**), the current display can be zoomed in. Each step of zooming (**ZOOM+** / **ZOOM-**) will increase or decrease the visible part by 2µs (200 Samples). The black stripe at the lower side of the display illustrates the relation of visible time to the total acquired time of 80µs (60µs). Shifting the left position of the visible area by pushing the buttons **POS>>** or **POS<<** enables to analyze the complete wave in a high resolution.

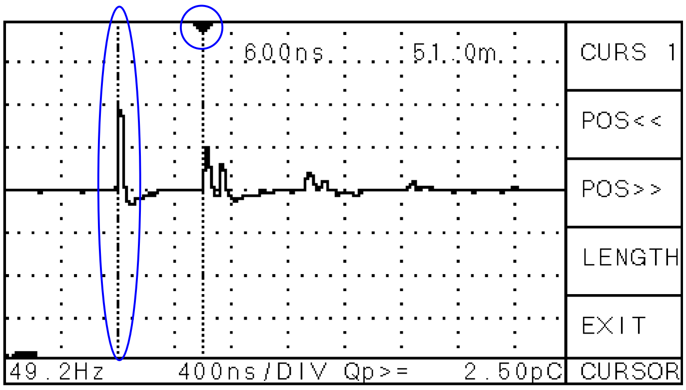


Fig. 54: Cursor Measurement on a PD pulse

The easiest way to evaluate the pulses is using the cursor functionality for the display. Two cursors are supported. Each of them can be set individual to a time position by pushing the buttons **POS>>** or **POS<<** within the menu CURSOR. Select first the cursor by pressing the upper button (**CURS1** or **CURS2**). Always the active cursor will be marked with a black filled triangle at the upper end of the vertical dotted line. It is best to hold first the running acquisition before setting the cursors. Moving the cursors will automatically calculate the new time distance and the result for the distance in meter (feet). These values can be read off from the upper border of the display. The distance on the HV cable is measured beginning from the far end of the measurement point (also see chapter III.3.2.1). A sensible result can only be ensured if the pulse velocity is set correctly.

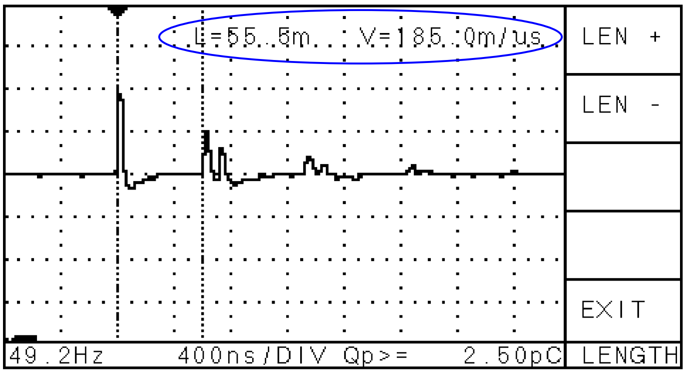


Fig.55: Cursor Settings: **L**ength and **V**elocity

The pulse velocity can be calculated if the cable length is know. For this a calibration impulse has to be injected into the near end of the cable. Caution: For calibration the HV supply has to be turned off!

Once the trigger is set to the first (largest) pulse, also the echoes become visible. Setting one cursor to the first pulse and the other to the second pulse will read the calculated cable length. Within the menu **LENGTH** the precise cable length can be set. The pulse velocity is then calculated automatically using the settings of the cursors which are displayed at the upper right hand side.

Another possibility to get the specimen settings is to modify the pulse velocity directly. This can be done in the menu **SPEED** which is accessible from the menu MODE_D. This function is useful if the cable length is not know but the type of cable. A calibration is not obligatory.

III.3.3.5 Key Menus for the DSO (Overview)

Followed menus are accessible with an ICM*compact* including the DSO for cable fault location.

GN/TRG
HOLD
MODE
SCOPE
SETUP
MAIN D

GN/TRG
Pushing this button changes to the submenu TRG_M. Within that menu the user can set the gain and trigger level for the PD display in time domain (DSO display).

HOLD / RUN
Pushing this button switches between Hold and Run mode for the DSO display.

MODE
Pushing this button changes to the submenu MODE_D. This submenu gives access to several settings of the DSO display as zoom, position and cursor settings.

SCOPE / METER
Depending on the switched on displays (see menu DISPL) this function switches o the next display type.

SETUP
Pushing this button changes to the SETUP menu. As there are several setup menus, this function enters ever in the last setup you've been once before.

ZM/POS
CURSOR
SPEED
UNIT
EXIT
MODE D

ZM/POS
Pushing this button changes to the submenu ZM/POS. Within that menu the user can set the zoom and the zero position for the DSO display.

CURSOR
Pushing this button changes to the submenu CURSOR.

SPEED
Pushing this button changes to the submenu SPEED.

UNIT
Pushing this button changes to the submenu UNIT.

EXIT
Pushing this button changes to the setup menu MAIN D.

GAIN+
GAIN-
TRGL+
TRGL-
EXIT
TRG_M

GAIN+/GAIN-
Pushing this button increments / decrements the total gain (details see above). These settings are independent from the gain settings in the menus SCOPE and METER.

TRG L+/TRG L-
Pushing this button displays and changes the trigger level. More details are described above.

EXIT
Pushing this button changes to the MAIN D menu.

ZOOM+
ZOOM-
POS>>
POS<<
EXIT
ZM/POS

ZOOM+ / ZOOM-
With these buttons the zoom can be adjusted. More details are described above.

POS>> / POS<<
With these buttons the displayed position can be adjusted. More details are described above.

EXIT
Pushing this button changes to the setup menu MODE D.

CURS 1
POS<<
POS>>
LENGTH
EXIT
CURSOR

CURS 1, CURS 2
Pushing this button toggles between the two cursors. The selected cursor is indicated by a black filled triangle at the upper end of the dotted cursor line.

POS<<, POS>>
Pushing this button will shift the selected cursor to the corresponding side. If the cursors are out of the display, push POS<<, POS>> or increase the ZOOM-.

LENGTH
Pushing this button changes to the menu LENGTH for setting up the cable length.

LEN+
LEN-
EXIT
LENGTH

LEN+, LEN-
Pushing this button changes the setting for the cable length. The calculated value for the distance between the two cursors can be set accordingly. This will change also alter the pulse velocity. Please regard the calibration described above.

EXIT
Pushing this button changes to the menu CURSOR.

SPEED+
SPEED-
EXIT
SPEED

SPEED+, SPEED-
Pushing this button changes the setting for the pulse velocity. This value is used to calculate the distance of the cursors.

EXIT
Pushing this button changes to the setup menu MODE D.

>m
ft
>mV
pC
EXIT
UNIT

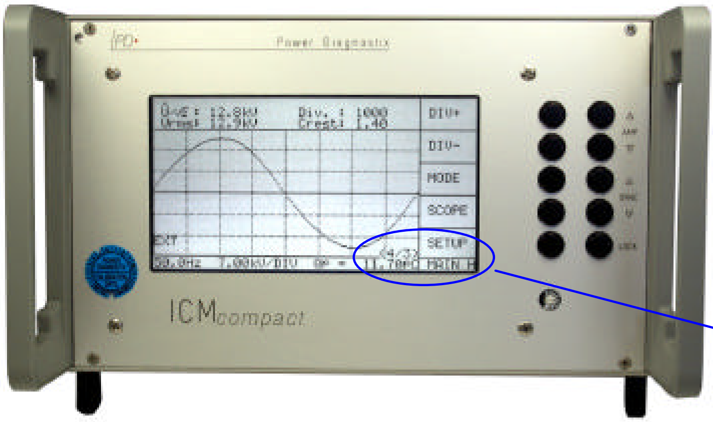
m, ft
Pushing this button enables (>) the relevant system unit. This setting is only accessible when the optional DSO is implemented.

mV, pC
Pushing this button changes the shown measurement value within the DSO panel.
'mV' is the peak value of the shown curve (single PD pulse),
'pC' is the peak charge value as shown in the SCOPE or METER display.

EXIT
Pushing this button changes to the setup menu MODE D.

III.3.4 MUX - Channel Multiplexer (optional)

Instruments with a built in (MUX) multiplexer are able to switch between 4 or 12 different channels. The front panel of an instrument with this option includes five extra buttons labeled '∆ AMP ∇', '∆ SYNC ∇' and 'LOCK'. These buttons enable to directly select one of the 4 or 12 signal sources. Hereby the partial discharge signal (AMP) and the voltage signal (SYNC) are split and can be selected separately. The gain setting, calibration factor and divider factor (if HVM is installed) are stored separately for each channel.



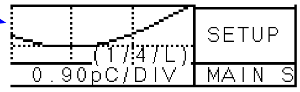


Fig. 56: ICM*compact* with MUX (multiplexer) and HVM   Fig.57: Status Display

In the lower right hand corner the selected channel is displayed. The first number indicates the AMP channel for the PD signal. The next number shows which channel is taken for the SYNC or voltage measurement. To avoid an unintended change of the channels, the 5 extra buttons can be locked and unlocked by the button 'LOCK'. This is indicated in the display by an 'L'. In the example in Fig. 57 channel 1 is selected for the PD signal, channel 4 for voltage measurement and synchronization. And the right keyboard is locked.

Fig. 58: Back panel of the ICM*compact* with MUX4 and AUX input

Two main multiplexer are available for the ICM*compact*:
1) 4x AMP and 4x SYNC
2) 12x AMP and 12x SYNC
(with external remote controlled box RB2/24)

III.3.5 AUX - Auxiliary Inputs (optional)

Up to 8 auxiliary input channels (AUX) can be ordered for the ICM*compact*. These inputs can be used to record extra signals like power, temperature, pressure etc. Commonly used input levels of either 4 to 20mA or 0 to 10V_{DC} are available. The rear panel of the instrument has one BNC connector for each AUX channel, as can be seen in figure 59.

Fig. 59: AUX input connectors

Caution: The AUX inputs are only to be connected with their designed signal magnitude. Overvoltage (e.g. from the signal for the SYNC input) might harm your instrument.

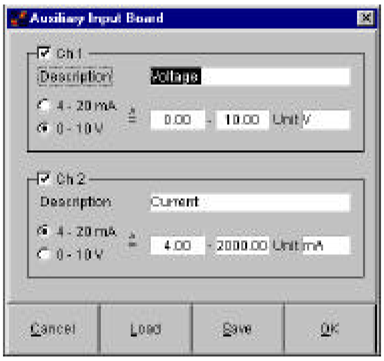


Fig. 60: Screenshot

A serial interface (RS232) is used to link the ICM*compact* instrument with the software, running on a standard PC. With this ICM*compact* software it is possible to label and scale the AUX inputs. Figure 60 shows the setup frame for a 2 channel system. Within the main frame of the software the processed AUX values are displayed together with the PD pattern and the voltage values (if the HVM is installed). Long term records of the PD, voltage and AUX data are easily done and can be exported to standard data file format. However, to access the AUX signal data, the ICM*compact* software is mandatory.

III.3.6 STP - Additional Setups (optional)

If the ICM*compact* is frequently used at different places, the optional function STP can store up to 12 different setups. Three extra buttons are added to the front panel to swap between the different setups. The top buttons 'Δ SETUP ∇' will change the setup number, whereas the lower button will lock this function. The current setup number is shown in the lower right corner

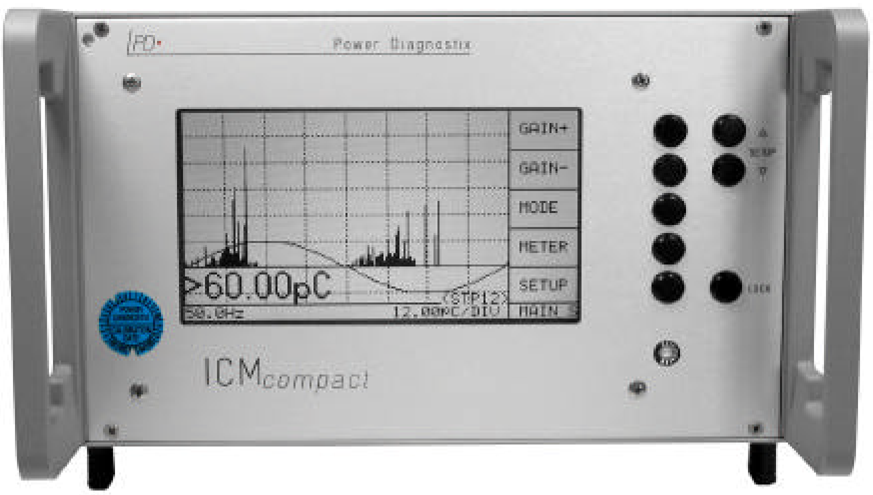


Fig.61: ICM*compact* with twelve selectable setups

III.3.7 LOG - Logarithmic amplifier (optional)

When capturing PD signals offering a larger dynamic range, e.g. in a GIS (gas insulated switchgear) the ICM*compact* can be ordered with a logarithmic scaling. For this, a logarithmic preamplifier, the RPA6C is required. This preamplifier also has the advantage to capture PD signals in a high frequency band (300MHz to 2GHz). Since the preamplifier itself has a large dynamic range, there is no need for adjusting the gain during measurements. Therefor, the functions 'GAIN + and 'GAIN –' are replaced by 'Range +' and RANGE –'. Using this buttons will not change the amplification of the signal, it just changes the range of the logarithmic scaling on the display. Figures 62 and 40 shows a 50pC calibration pulse in the meter and scope display mode.

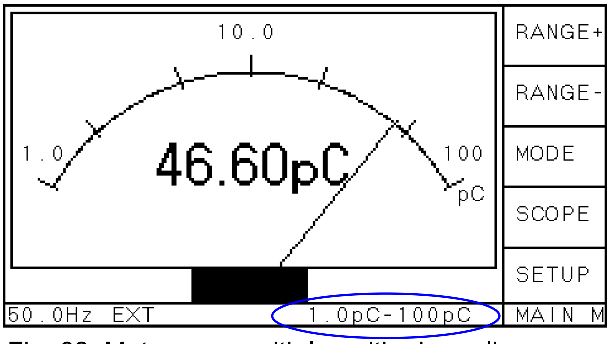


Fig. 62: Meter menu with logarithmic scaling

Since the RPA6C has got a fixed bandwidth of 300MHz to 2GHz, the internal filter settings are disabled. Be aware that PD pattern will look different on a logarithmic scaling and need some experience for the analysis.

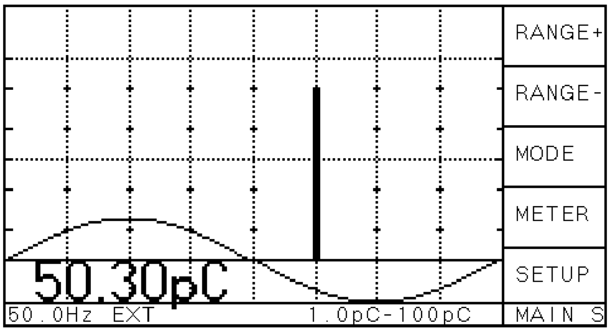


Fig.63: Scope menu with logarithmic scaling

While the gain setting is disabled in the measurement menus, it is however possible to adjust the internal gain to the application. This has to be done before the system is calibrated. A later change of the gain will need a new calibration. The calibration should be done with a simulated PD pulse close to the expected PD in respect of location and magnitude (see also chapter III.4). The gain should then be set to about 50% of the maximum input level. This signal input level is indicated by L=50%. Then the injected PD pulse magnitude can be set with 'CAL +' and 'CAL –'. After pressing one of the 'CAL' buttons, the calibration factor is calculated and stored in a non-volatile memory.

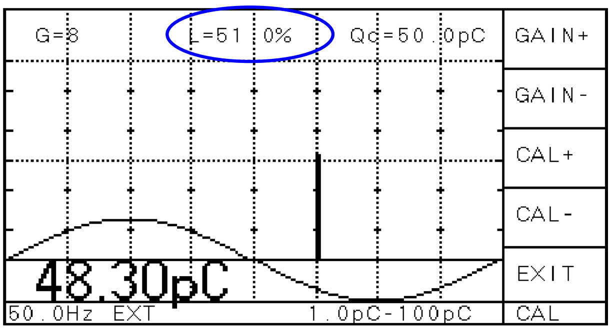


Fig. 64 Calibration mode

III.4 Calibration

PD measurements refer to the apparent charge and are relative measurements. Therefore, each new installation, changes of relevant quantity (e.g. bandwidth, coupling capacitance etc.) requires a new calibration. This is done by injecting a known PD pulse close to the origin of the real PD source (test object) and from this calculating the scale factor for the measurement. The injected PD pulse should be in the range of 50% to 200% of the expected PD magnitude.

III.4.1 Calibration Impulse Generator

There is a broad range of impulse generators offered by Power Diagnostix for different purposes. Table 2 gives an overview of these calibrators. All calibrators allow the calibration of PD measurements according to IEC60270 / 2000, except the CAL2B. Since the CAL2B has left out the injection capacitor to enable calibration on GIS.

Calibration Impulse Generator	Range	Output	Frequency
CAL1A	1, 2, 5, 10, 20, 50, 100pC	Injection Capacitor <1pF	50Hz (60Hz)
CAL1B	100, 200, 500pC, 1, 2, 5, 10nC	Injection Capacitor <100pF	50Hz (60Hz)
CAL1C	1, 2, 5, 10, 20, 50, 100pC	Voltage output (50Ω)	50Hz (60Hz)
CAL1D	10, 20, 50, 100, 200, 500, 1000pC	Injection Capacitor <10pF	50Hz (60Hz)
CAL1E	0.5, 1, 5, 10, 20, 50nC	Injection Capacitor <500pF	50Hz (60Hz)
CAL1F	0.2, 0.5, 1, 2, 5, 10, 20nC	Injection Capacitor <200pF	50Hz (60Hz)
CAL1G	0.02, 0.05, 0.1, 0.2, 0.5, 1, 2 nC	Injection Capacitor <20pF	50Hz (60Hz)
CAL2A	0.5, 1, 2, 5, 10, 20, 50pC	Injection Capacitor <1pF	50Hz (60Hz)
CAL2B	0.5, 1, 2, 5, 10, 20, 50V (into R_L=50Ω)	Voltage output (50Ω)	50Hz (60Hz)
CAL2C	0.2, 0.5, 1, 2, 5, 10, 20V (into R_L=50Ω)	Voltage output (50Ω)	50Hz (60Hz)

Tab. 2: Output and Frequency Ranges of PD calibrators

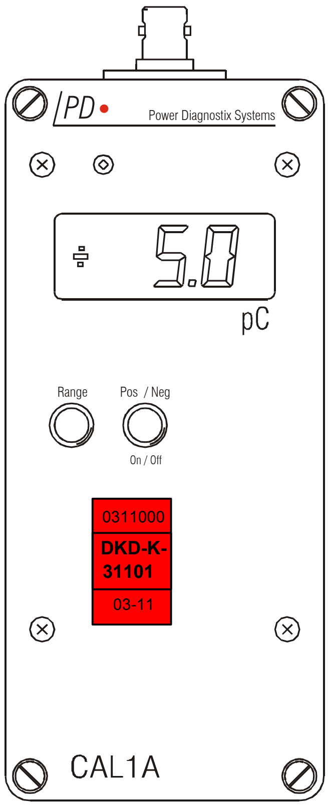


Fig. 65: Calibrator

All calibrators are switched on with the pushbutton On/Off. Both amplitude (Range) and polarity (Pos/Neg) of the single charge pulse per cycle are displayed and can be adjusted by pressing of the two buttons. The instrument is synchronized to line frequency by a photo diode. In case of insufficient pick-up of power frequency light, it will select automatically the internal quartz oscillator (50Hz and 60Hz versions available). The button On/Off must be pressed for more than 1 second to switch the pulse generator off, while automatic switch-off occurs after approximately 15 min.

Operation time of up to 200 hours are obtainable with the 9V lithium battery due to an average supply current of approx. 5mA (quiescent current is negligible). An alkaline battery resulting in approx. 90 hours of continuous operation may replace the lithium battery. A weak battery is indicated by the LO BAT sign of the LC display.

Warning: While changing battery, be aware of internal parts carrying up to 125V of DC potential!

Power Diagnostix delivers their standard calibrators with a fully traceable DKD calibration (DKD-K-31101). This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI). The DKD (Deutscher Kalibrierdienst) is signatory to the multilateral agreement of the European co-operation for Accreditation (EA) for the mutual recognition of calibration certificates.

III.4.2 Calibration test set up

The entire signal path from the discharging source to the instrument, as well as some instrument properties as filters, for instance, are introducing an overall attenuation which is not precisely known. Thus the calibrator (CAL1A or equivalent) has to be connected to the actual PD source as close as possible. Figure 66 shows an example of a calibration circuit diagram.

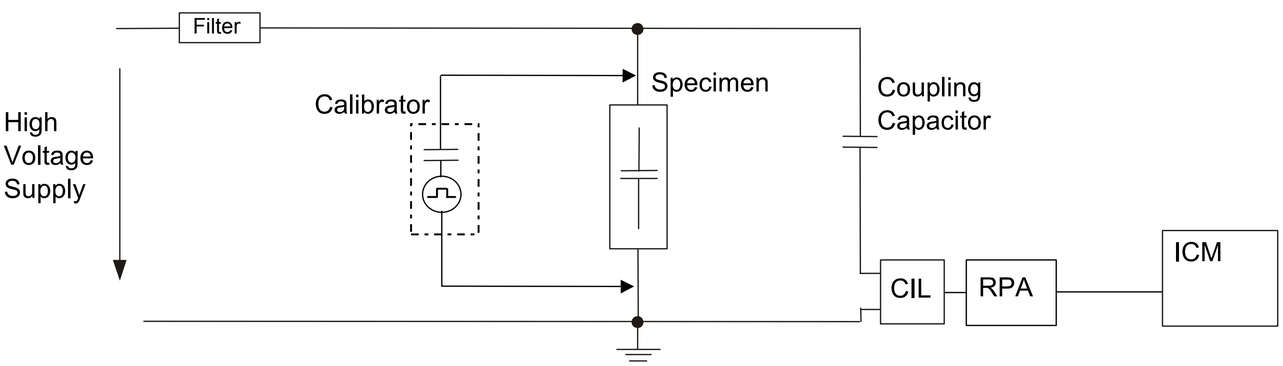


Fig. 66: Example of calibration set up

To calibrate a test setup where a current transformer (as CT1 or CT100) is used, place the positive clip of the calibrator on the high voltage side of the test object, and the negative clip of the calibrator on the low voltage side of the test object. This will ensure that the calibration pulse will take the same signal path as the actual PD pulse.

III.4.3 Calibration menu

The ICM*compact* offers a calibration menu (CAL) which can be found as first item in the menu SETUP1. To have the complete information for doing the calibration, it is best to be in the SCOPE display. However, the menu CAL is not available, when the optional displays HVM, or DSP are visible. Fig. 67 shows the calibration menu in the SCOPE mode.

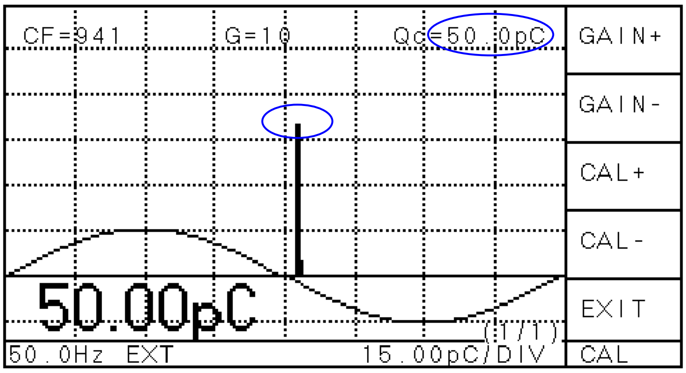


Fig. 67: Scope Display during Calibration

Once the calibration pulse is displayed on the screen, GAIN+ and GAIN– should be used to place the calibration signal reading between 50% and 90% of full scale (i.e. 4 divisions, since maximum is at 5 divisions). The CAL+ and CAL– buttons then adjusts the calibration value (shown in the upper part of the display). This value has to be set equal to the one on calibration impulse generator. The calibration factor (CF) is calculated accordingly. There is no possibility to make it undo!

Calibration factor and all other parameters remain stored when the system is switched off and are automatically recalled when the system is switched on again. Be sure, that the calibration is only changed in case of test setup modifications to keep the integrity of the monitoring results.

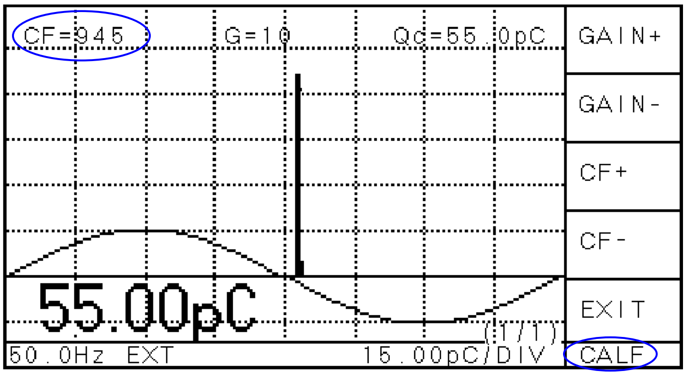


Fig. 68: Setting the calibration factor

If the calibration factor is known from previous calibrations or from an identical test setup, it is also possible to directly enter this value. In the menu 'CALF', the calibration factor can be entered directly. For this change, it is not necessary to adjust the gain, since there is no processing of the measurement value. The calibration factor (CF) is displayed in the top left corner and relates to a virtual gain of 1.

The software ICM*compact* and HV*pilot* offers to save the whole instrument settings (as *.cmp rep. *.hvp) and thus enables to repeat a test with same the settings and calibration. For using a stored calibration, it has to be ensured, that the test circuit is the same. For saving and loading the instrument settings, see the respective software manual.

Caution: For calibration the system has to be de-energized.

III.5 Noise Reduction

III.5.1 LLD noise ground (Low-Level Discriminator)

Depending on the environment and the test circuit, different level of background noise are visible (see Fig.69). Since this noise level is usually stable for the whole phase (360°), it can be removed by the LLD function (low level discriminator). All PD pulses falling beneath the LLD-threshold are deleted. This will remove broad black band in the NORM, SINUS mode of the SCOPE display.

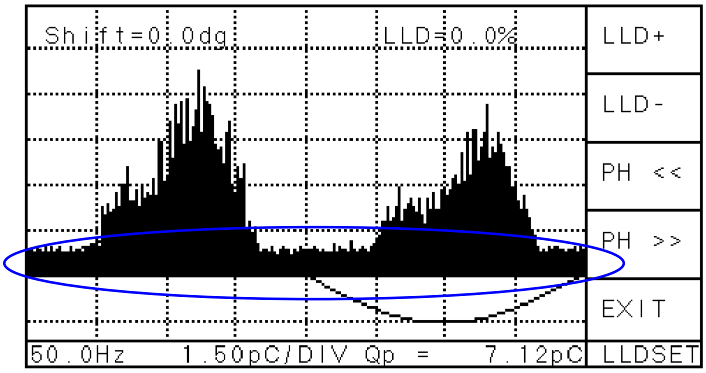


Fig. 69: PD pattern including noise level (LLD=0%)

The LLD can be set in the menu SETUP2 \ LLD/P by the buttons LLD+ and LLD-. The standard setting is 10%. The LLD function is not active in the METER display.

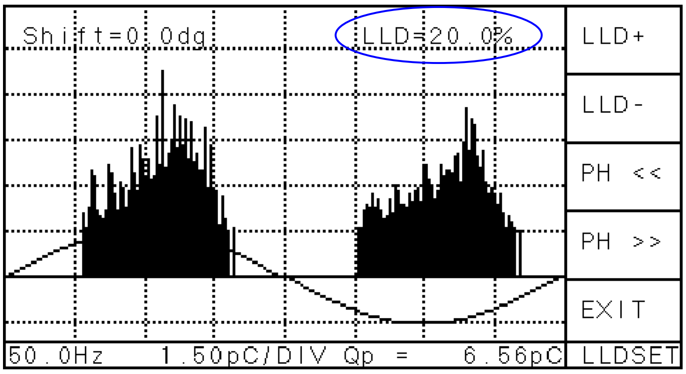


Fig. 70: PD pattern without noise level

III.5.2 Window Mask (Software)

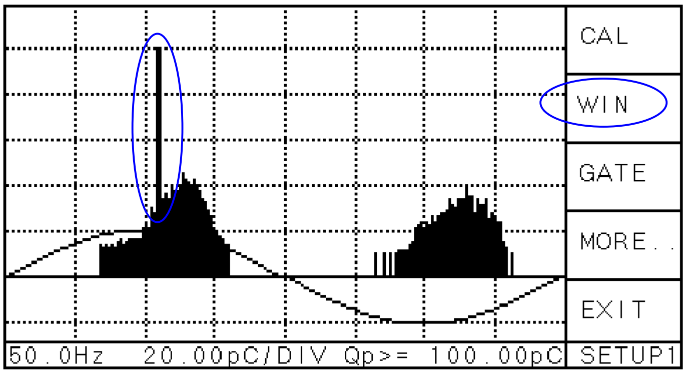


Fig. 71: PD pattern with one phase stable disturbance

Some disturbances like thyristor firing are phase stable. They can be removed by the software function WIN. This function selects up to 3 windows which blank out pulses occurring in these windows. Pulses occurring within these windows will neither contribute to the displayed charge peak value of the SCOPE display, nor will they affect the reading of the meter.

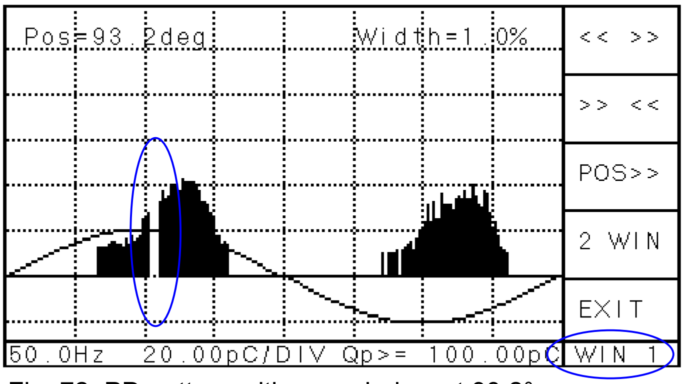


Fig. 72: PD pattern with one window at 93.2°

Fig. 71 and Fig. 72 show the same measurement, whereby in Fig. 72 one window is set to blind the respective phase position.

The menu SETUP1 \ WIN offers to set 0 to 3 windows. The number of windows can be changed by ‘OFF’, ‘1 WIN’, ‘2 WIN’, ‘3 WIN’ and is displayed at the bottom line. The width of each window is identic and can be increased by ‘<<>>’ or decreased by ‘>><<’. The phase position is changed by ‘POS>>’.

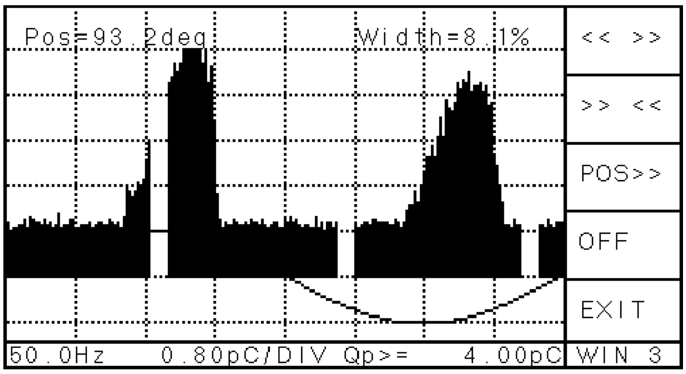


Fig. 73: Three windows of 120° distance, LLD=0%

If a second windows is selected the distance to the first will be 180°, for three windows the distances are 120°.

As in the previous menu, the window parameters remain stored after deactivating the window function or when the instrument is switched off.

III.5.3 External Signal Gating (TTL Gating, optional)

If disturbances, like switching of a relay or thyristor firing, have a known source, it might be possible to create a TTL signal prior to the disturbance. This signal can be used to blind out the PD measurement path. The TTL gating function is an optional function and has to be ordered separately. ICM*compact*’s with this optional function have a BNC connector on the back panel labeled ‘TTL gate’. For the time this input is logically high ($5V_{DC}$; TTL standard) no signal is taken from the AMP_IN terminal i.e. no PD signal is recorded.

III.5.4 Gating With External Sensor (Optional, Analog Gating)

An effective noise reduction is required in case the ICM*compact* is used for partial discharge measurements in an environment with high frequency (HF) disturbance. HF disturbances, which hamper partial discharge detection and which can be handled by the gating function are, for instance, radar signals, corona discharge, or thyristor firing. Using the analog gating function blind out such impulse noise. Continuous radio frequency signals from broadcasting, for example, cannot be removed by the gating function. Here, the active bridge adapter AB1 is used.

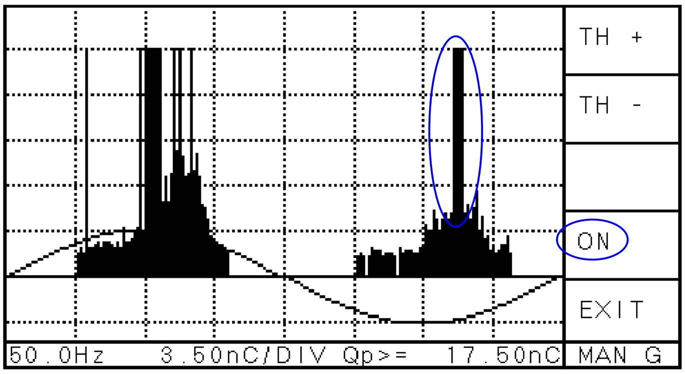


Fig. 74: PD pattern including disturbances

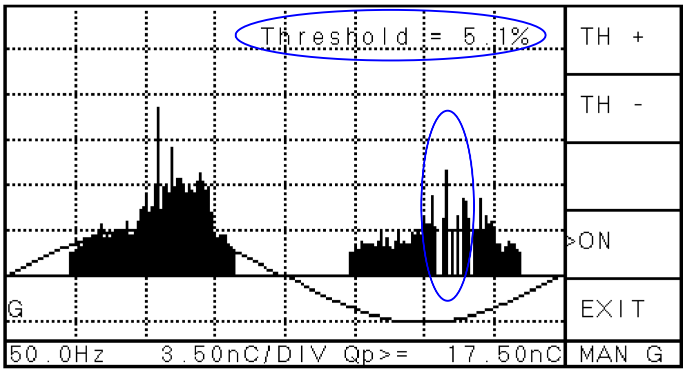


Fig. 75: PD pattern after manual gating

The analog gating function is an optional function and has to be ordered separately. An ICM*compact* with a gating function comes with a built-in preamplifier (RPA6) and a 'GATE IN' terminal (BNC) on the rear panel. An antenna or another sensor that picks up the disturbance signal is connected to this 'GATE IN' terminal. With some applications a CT1 (current transformer) is used to acquire the disturbance signal from a ground conductor or from the screen of a signal cable.

The gating function is activated in the menu MAN G or AUTO G (see chapter III.2.2 Optional Key Menus). '**>**ON' indicates activated gating. In case the (disturbance) signal at 'GATE IN' terminal exceeds a threshold the processing of the analog signal is blocked for 10 to 100µs. Thus, the signals falling in this period does not contribute to the instrument's display and derived quantities.

Two different modes of setting the trigger can be selected from the menu 'GATE':

MAN - The manual mode offers to set the trigger from 1 to 100 % of the peak disturbance level. This threshold is displayed in the upper right corner of the display (MAN G) once this mode is active. To change the trigger level press 'TH +' and 'TH –'. This option is used to remove a known disturbance source in a stable environment.

AUTO - The automatic mode calculates a gating time as a fixed portion of the measured time. E.g. setting the gating time to 10% results in a total blind-out time of 2ms for 20ms @ 50Hz. The trigger level will be set accordingly to this time. The total gating time, when activated, is displayed in the upper right corner of the menu 'AUTO G'. Pushing 'GT +' and 'GT –' allows changing the gating from 1% to 50%. This option is used to when the noise situation is likely to change over time.

Bandwidth Mode	Frequency Range
MODE1	40kHz to 800kHz
MODE2	2MHz to 20MHz
MODE3	200MHz to 600MHz

The built-in preamplifier (RPA6) has a logarithmic amplification and can be set to three different frequency ranges, which are selected in the submenu 'BANDW'. The active bandwidth mode is marked by '>'. The following table lists the frequency bands for the three modes.

An ICM*compact* equipped with the gating function offers the following additional menus. They can be accessed only in the 'SCOPE' display 'SETUP'/'GATE' menu:

MAN
AUTO
BANDW
EXIT
GATE

MAN
Pushing this button changes to the submenu for manual gating (see below).
AUTO
Pushing this button changes to the submenu for automatic gating (see below).
BANDW
Pushing this button changes to the sub-menu, where the frequency bands of the preamplifier (RPA6) can be set (see last menu bar on this page).
EXIT
Pushing this button changes one level up to the menu SETUP1.

TH+
TH-
>ON
EXIT
MAN G

TH+/TH-
Pushing these buttons increments or decrements the gating threshold level. This value is displayed at the upper right side of the screen in percent. If the gating analog signal exceeds this level, then the measurement PD signal is blocked for 100µs at 50Hz. The gating time per noise event T_g depends on the synchronization frequency and is calculated by (where f_{sync} is the sync frequency displayed in the left bottom corner of the display):

$$T_g = \frac{1}{f_{sync} \cdot 197}$$

ON (>ON)
This button turns the gating function on (>ON) or off (ON). The gating function remains off, if no preamplifier is connected to the gating input. Usually, the preamplifier is build in.
EXIT
Pushing this button changes one level up to the menu GATE.

GT+
GT-
>ON
EXIT
AUTO G

GT+/GT-
Pushing these buttons increments or decrements the total gating time. This value is displayed at the upper right side of the screen in percent. The instrument automatically adjusts the threshold level. If the gating signal exceeds this automatically set level, then the PD signal (AMP IN) is blocked for maximum 100µs at 50Hz.
ON (>ON)
This button turns the gating function on (>ON) or off (ON). The gating function remains off, if no preamplifier is connected to the gating input. Usually, the preamplifier is build in.
EXIT
Pushing this button changes one level up to the menu GATE.

MODE1
MODE2
>MODE3
EXIT
BANDW

MODE1
Pushing this button selects the frequency range 1 (40kHz to 800kHz) for the preamplifier RPA6 at the gating input.
MODE2
Pushing this button selects the frequency range 2 (2MHz to 20MHz) for the preamplifier RPA6 at the gating input.
MODE3
Pushing this button selects the frequency range 3 (200MHz to 600MHz) for the preamplifier RPA6 at the gating input.
EXIT
Pushing this button changes one level up to the menu GATE.

IV The ICM*compact* Software (overview)

There are two software packages available to communicate with the ICM*compact* via serial link (RS232).

- **ICM*compact*** : Standard software to record and save PD measurement data.
  Optional version for the cable fault location, only to use with the DSO extension.
- **HV*pilot*** : Used to take measurements over long periods. Useful only with the STEP*compact*.

Software has to be ordered separately and is delivered on a CD ROM. Software updates can be downloaded from Power Diagnostix' home page (www.pdix.com) using a valid login and password. After downloading the requested software and extracting the files, the program 'setup.exe' will start the installation.

V Standard Software ICM*compact*

The standard software is also called ICM*compact* and shows an image of the LCD (display) from the instrument. The acquired data, like PD, voltage (if the optional HVM installed) and AUX (if installed) are constantly refreshed. The five menu buttons can be used like on the real instrument which allows a remote control even over longer distances. For this, the serial link can be extended by a fiber optic or in combination with a modem on both sides (instrument and PC) by a common phone line.

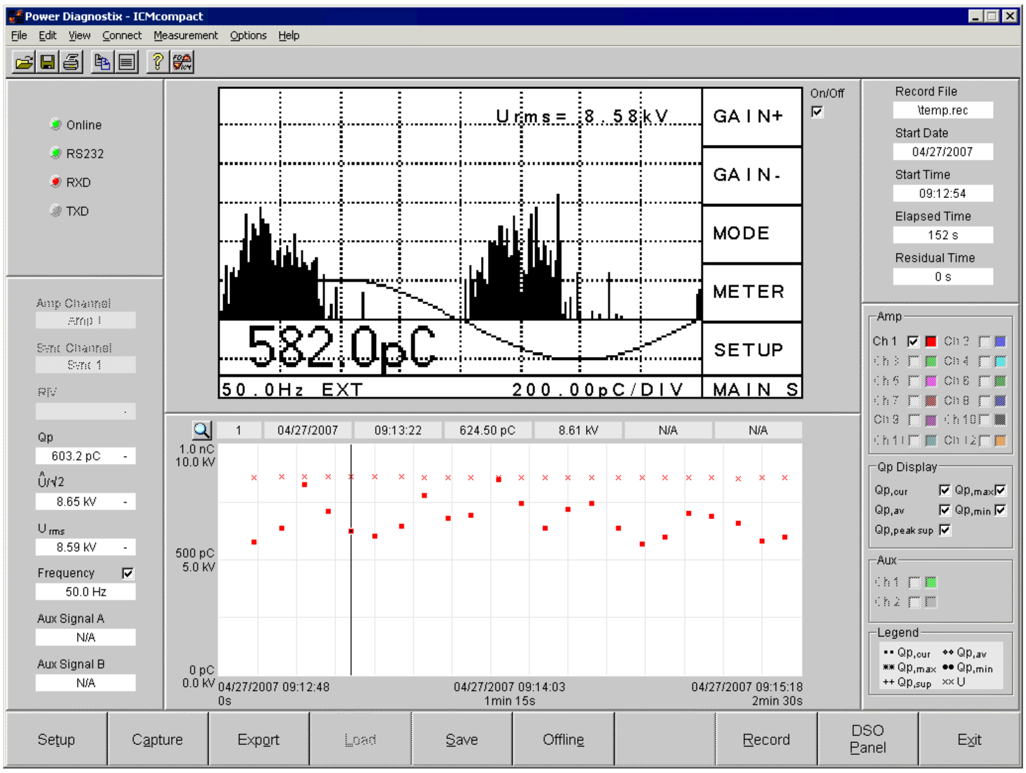


Fig. 76: Main Control Panel of the standard software ICM*compact*

The ICM*compact* software can be used online and offline. In the first online session the device code of the instrument has to be entered to keep the serial connection. The PC will then actively communicate with the instrument and take the PD pattern and measurement values. These acquired data can be stored and exported in different ways, so that a repetition or later analysis of the measurement is feasible. The export functions allow an easy way to create reports with all necessary information like data, pattern and graphs.

VI Extended Software 'ICM*compact*' with cable fault location

The optional software extension for cable fault location is specialized for high or medium voltage cable diagnostic. This requires an ICM*compact* instrument with the optional acquisition board 'DSO'. For the general functionality of this board and a detailed description of this software extension, see also chapter III.3.3 'DSO Display'. Older instruments can be upgraded with the DSO board, please contact Power Diagnostix for details.

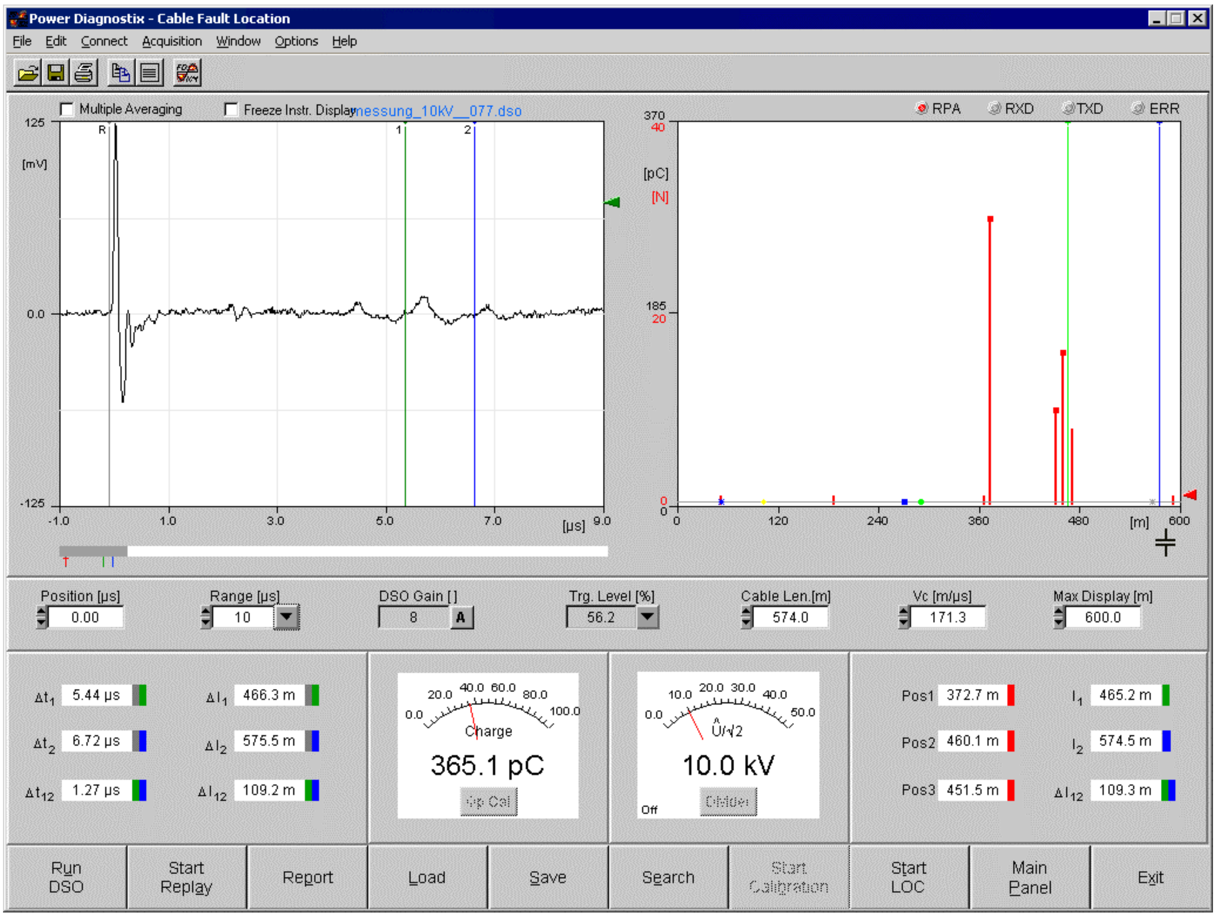


Fig. 77: Main Panel of ICM*compro* with the DSO graph (left) and the LOC graph (right)

The main panel shows in the top part two graphs (DSO left and LOC right) as can be seen in Fig. 77. On the left hand site the **DSO** graph (digital storage oscilloscope) displays the actual PD waveform including its reflection at the cable terminations. This is in principle the same graph as shown on the display of the instrument just with a higher resolution. The software offers three colored cursor to evaluate the PD pulse. Since the time difference of the reflections refers to the fault position, the calculated values in time and meter/feet are listed in the field below (see figure left 78)

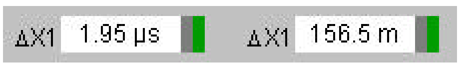


Fig.78: First Evaluation Result from DSO graph

Usually multiple PD pulses are recorded and evaluated. This ensures to capture further PD sources and to state more precisely the position of single defects. The graph on the right hand site collects the results from the distance evaluation of the DSO graph. This localization graph (**LOC** graph) is usually created offline by a manual or automatic mode. It requires for the calculation either the total cable length or the pulse velocity. The number and charge of all captured PD pulses is then displayed as a function of the cable length. Finally the fault positions can be measured by two cursors (blue and green) directly.

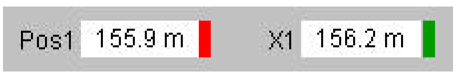


Fig.79: Final Fault Position from LOC graph

VII Specialized Software HV*pilot* (optional)

The HV*pilot* software is designed to control the voltage for a test set up and to take measurements of: voltage (high voltage site), partial discharge (PD), tanδ (dissipation factor) , Cx (ideal capacitance of the test object).

For this task, three further instruments beside a PC are necessary:

- the STEP*compact* to control the variac of a high voltage transformer, observing the voltage for a possible break down, and supply the HV*pilot* with the actual voltage value.
- the ICM*compact* to take PD measurements of the test object.
- the TDA*compact* (optional) to measure the tanδ and capacitance of the test object.

The STEP*compact* together with the HV*pilot* software are newly developed to automate high voltage test sequences. The three instruments are connected to a PC via serial link (RS232) and exchange data with the HV*pilot* software. This software also provides the possibility to program a test sequence, analyze the measured data and generate a report automatically. Several different test sequences can be created to customize the program for special measurement tasks. The report files are created as *.doc or *.html and can also easily be customized.

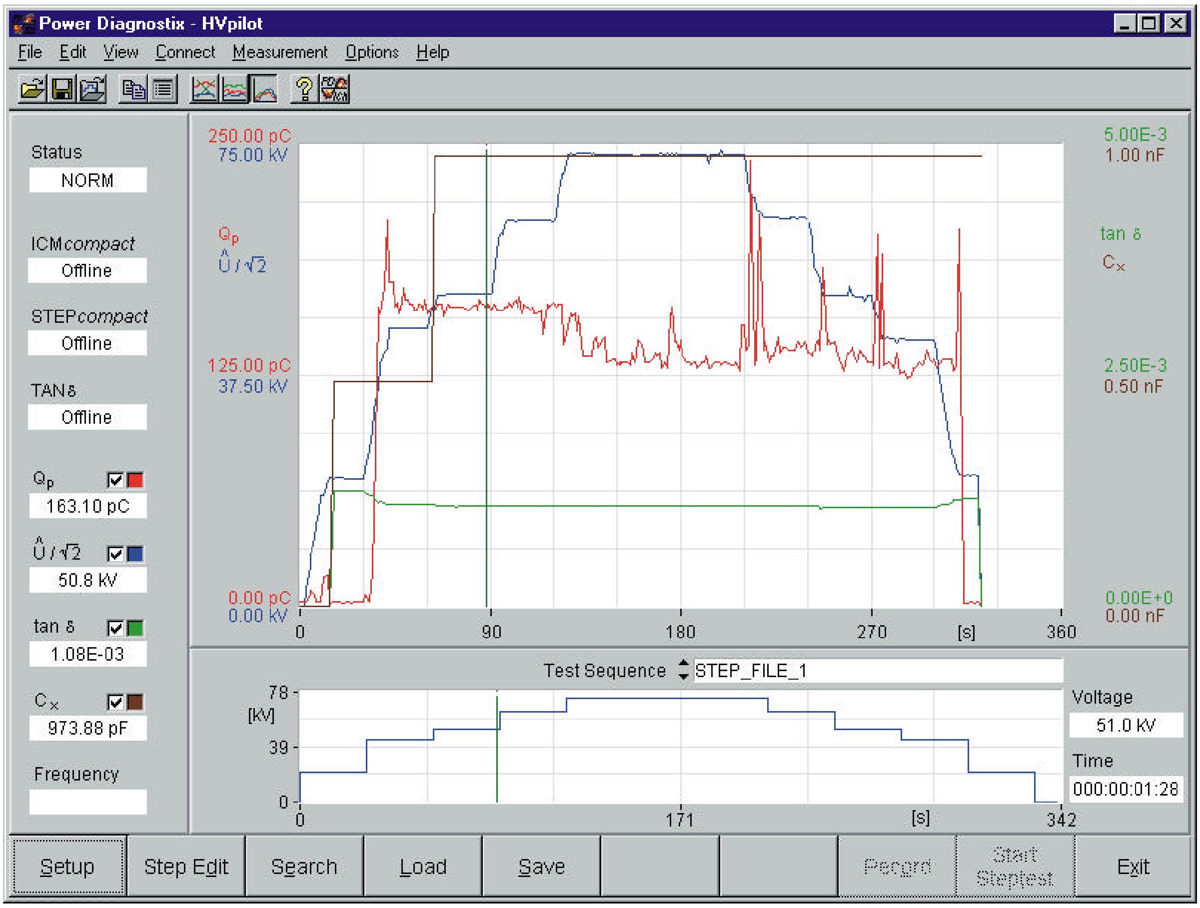


Fig.80: Main Panel of the HV*pilot* software for the automation of high voltage tests.

The main panel of the HV*pilot* software displays the 4 measurement values (Û/√2, PD, tanδ, C_X) continuously on a time axis. Beneath this, the programmed test voltage curve is displayed to follow a running test or to compare the measured data later on. Actual measurement values from the cursor position are displayed on the left hand site. The ten function buttons in the bottom row give a quick access to the main program functions.

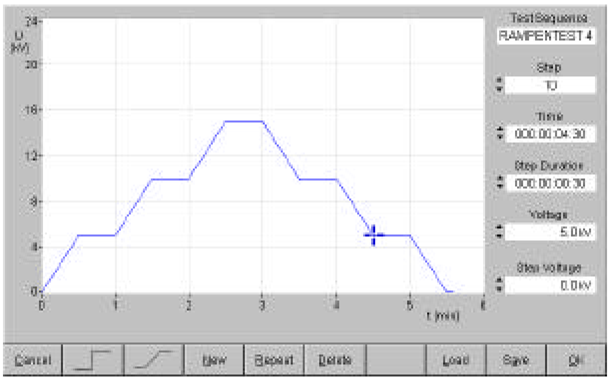


Fig. 81: Panel to create the step voltage curve

The first step to create a test sequence is the step voltage curve. This can be done offline (without the instruments) and downloaded later to the STEP*compact* (for the voltage control). Fig. 81 shows the function panel to create the step voltage curve.

The next step is to define the kind of test, which has to be done. Three different kinds of test sequences are offered:

- The first is designed for tests which plainly acquire the PD activity and the tan δ / C_X at predefined voltage levels.
- The second allows to set maximum PD levels at certain voltage values for e.g. acceptance tests.
- The third is designed for breakdown tests. E.g. several test specimen have to withstand an over voltage for a certain time. The voltage is increased continuously stepwise, and the test procedure must be continued after a failed specimen is removed.

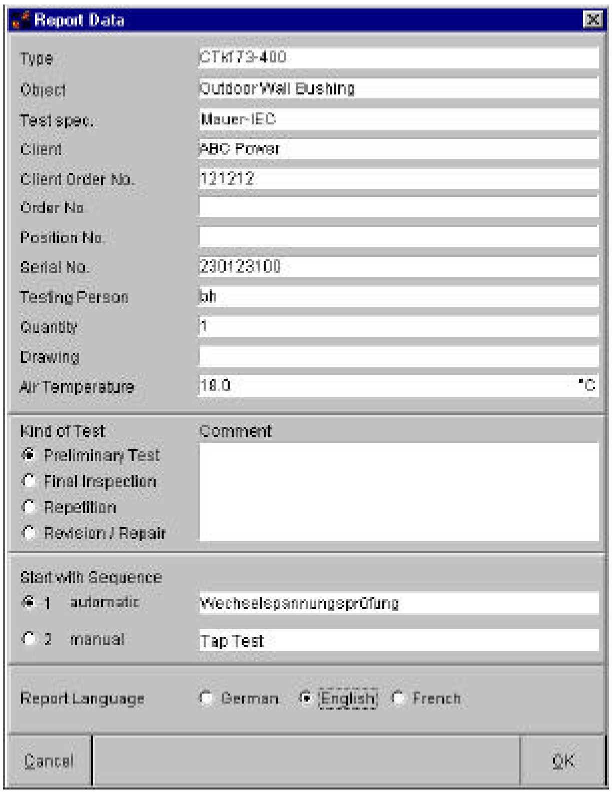


Fig. 82: Specification Field

Once the test sequence is specified and saved, the automated test can be started by loading the wanted sequence. The specification data for the report have to be entered and the test can be started. The test report will then be saved as can be seen in figure 82.

Test Report

230123001
Reference No.

Object	: **Outdoor Wall Bushing**	Quantity	: 1
Type	: **CTkf 73-400**	Drawing	:
Client	: ABC Power	<u>Preliminary test</u>	
Client Order No.	: 121212	Test spec.	: IEC 137

Serial No. : 230123100

1. Tests carried out

1.0 Tightness test 1,5 bar rel., 1 hour
1.1 Measurement of dielectric dissipation factor and capacitance: see pos. 3.
1.2 Measurement of dielectric dissipation factor and capacitance: see pos. 3.
1.3 Check of dielectric dissipation factor and capacitance: no change
1.4 Measuring tap test 3 kV, 50 Hz, 1 min., carried out together with the measurement of capacitance: see pos. 3.

2. Test conditions

Test date :
1.1 to 1.4 : Bushing complete, lower part in oil / Ambient air temperature ≈ 18.0 °C
1.2 : Measuring circuit acc. IEC 270 / Measuring instrument: ICMcompact / Background noise: 2 pC

3. Individual results

	1.1		1.2		1.4	
U (kV)	tanδ (%)	C (pF)	PD (pC) ↓	PD (pC) ↑	C (pF)	tanδ (%)
3.0					9701	0.173
21.0	0.109	885				
44.0	0.110	902	128	136		
51.0			131	137		
63.0	0.110	915	↓	↑		

4. Assessment

The bushing corresponds to the test specification.

Edition A Issued by: bh Manager testing section:

5. Remark

PD Bruesseler Ring 95a
52074 Aachen Tel. +49 241 74927
Germany Fax +49 241 79521

Power Diagnostix

Fig. 83: Example Report

VIII Miscellaneous

VIII.1 Maintenance

The ICM*compact* does not require any maintenance on a regular basis. There is no fine adjustment on a regular basis required, as the partial discharge measurement is a relative measurement that is calibrated with a reference source prior to a measurement. The calibration impulse generator as the reference source, however, must be calibrated on an annual basis to ensure that its output signal remains within the recommended boundaries.

VIII.2 Shipment Instructions

In case a unit needs to be returned to the factory, make sure the acquisition unit is packed safely. As the units are relative small, shipment by couriers, such as DHL, FedEx, or equivalent is the recommended mode of transportation. If possible, declare the instrument as 'used instruments for evaluation' at a relative low value. Consult Power Diagnostix for further details. Additionally, Power Diagnostix may provide you with a temporary replacement unit, in case of urgent needs.

VIII.3 Declaration of Conformity

Power Diagnoxtix Systems GmbH
Brüsseler Ring 95a
52074 Aachen
Germany

declares, that the instrument as specified below, meets the requirements of the standards and/or normative documents as listed below.

Subsequently the instrument complies with the requirements of the EMC directive 2004/108/EC.

Partial Discharge Detector

Product: ICM*compact*

Description: Partial discharge detector for use in high voltage test area

Standards: EN 61000-6-1, EN 61000-6-2
EN 61000-6-3, EN 61000-6-4
EN 61010-1

Date:

Detlev Gross (managing director)

Remark: Since the measurement of partial discharge pulses is done in frequency bands partly occupied by radio transmission, and since further test leads may act as antennas, disturbance free measurements may require well shielded environments and/or additional filter techniques.

IX FAQ (Troubleshooting)

This chapter lists some problems that may be encountered in using the ICM*compact* along with possible causes and remedies.

The ICM*compact* doesn't do anything when powered up.
The power fuse might be blown. Unplug the unit and check the power supply fuse. This fuse is located on the rear panel of the ICM*compact* beneath the on/off switch (see figure 6 chapter II.1.2).

The personal computer cannot find the ICM*compact*
A communications error with the serial connection to the ICM*compact* might have occurred. Within the ICM-*compact* PC software, check to be sure that the serial com port selected in the menu 'Connect' is the com port to which the ICM*compact* is actually connected.
Try rebooting both the ICM*compact* and the PC.

The 'RPA?' message appears in the lower left portion of the data display of the LCD panel, even though the RPA (preamplifier from Power Diagnostix) is connected.
The RPA might be installed improperly (backwards). Check to be sure that the BNC connector marked leads from the sensor (quadrupole, CT, or coupling capacitor), and the BNC connector which is marked by the sign leads to the BNC connector labeled 'AMP IN' on the rear panel of the ICM-*compact*.

The pre-amplifier must be enabled if a RPA is connected. Ensure the **>**RPA ON is marked (see chapter III.2.3). Try substituting other BNC cables to be sure that the problem is not in the cables themselves.

The calibration pulse is not visible on the LCD panel.
First check that the calibrator is still on. The calibrator will shut off automatically after several minutes without having its buttons pushed. Check that the low battery indicator is not showing on the LCD panel of the calibrator.

The calibration pulse setting might be too weak for the test setup. Try increasing the magnitude of the calibration impulse applied to the test setup.

The calibration pulse onscreen might be present but too small to be easily visible. Try putting the ICM*compact* into 'Scope Display' \ 'Norm' mode. This will make the calibration pulse appear as a vertical bar, which makes it easier to see onscreen that it appears in the 'Hold' mode.

Sometimes the calibration pulse is lost if the high-voltage power supply is connected to the test setup when the calibration is performed, even if the high-voltage supply is completely powered off. Try physically disconnecting the high-voltage supply from the test setup during calibration. The calibrator will then be connected across only the test object quadrupole, and the coupling capacitor (if present).

If the problems persists, please contact Power Diagnostix for technical support.

Other problems
The troubleshooting section of the ICM*compact* manual is evolving. If you encounter problems with your ICM*compact* that you think would be helpful to add to this troubleshooting section, please submit them to Power Diagnostix. Thank you for your assistance.

X Technical Data of the ICM*compact* (standard)

Mains Supply:	85-264V_{AC}, 47-440Hz	(automatic)
Line Fuse:	1,6 A	(time-lag)
Power Requirements:	approx. 20VA	
Display:	backlit LCD	
Display Resolution:	128 x 240 Pixel S/W	
Operation:	5 menu supported pushbuttons	
Input Impedance (PD):	10kΩ//50pF 50Ω	(RPA1-Input) (AMP IN)
Input Sensitivity:	< 200µV < 2mV	(RPA1-Input) (AMP IN)
Lower Cut-Off (-6dB):	40, 80 or 100kHz	(software controlled)
Upper Cut-Off (-6dB):	250, 600 or 800kHz	(software controlled)
Synchronization:	Line, with automatic change to external	
Synchronization Range:	10Hz - 210Hz 10Hz - 410Hz	(with HVM and VLF option) (>Vers.2.48)
optional:	10Hz - 510Hz	(on special order)
External Synchronization:	max. 100V_{rms} or ±200V_{peak} into 1MΩ // 200pF	
Recorder Output:	0-10V with R_O=100Ω	(re-converted analog value of the meter reading)
Operation Temperature:	10-40°C	(non condensing)
Size:	Width: 236mm Height: 133mm Depth: 300mm (exclusive BNC-Connectors)	
Weight:	approx. 3kg	

X.1 ICM*compact* with 'HVM' (integrated voltage measurement)

(The HVM option is mandatory for the VLF option)

Input:	"SYNC IN"	
Maximum level of voltage input:	$\pm 200V_{peak}$ into 1MΩ // 200pF	
Input Impedance:	10 MΩ // 200pF (with VLF option switched on) 1MΩ // 200pF	
Synchronisation:	10Hz - 210Hz	(>Vers.2.48)
optional:	10Hz - 510Hz	(on special order; not with VLF)
A/D Converter:	±11bit	
Samples:	197 samples per cycle e.g.: 20ms at 50Hz -> ≈100µs window per sample	
Divider Ratio:	adjustable via DIV+/DIV- push buttons	
Precision:	<1.5% (typical)	
Values displayed:	U_{RMS} -value, Û/√2 -value, crest factor	
Adapted Display:	The voltage curve is adjusted automatically to the range of 90 pixels of the display; the curve is plotted 1:1 if the level of the input voltage is below 2.5V;	
New menus:	at METER Display: HVM (2.buttons), Switch to voltage display HVM (High Voltage Meter); at HVM Display: MODE (3. buttons), sub-menu to set the shown voltage values at the scope display; at SETUP sub-menu: Display HVM can be turned off	
Additional software features:	"Data Record" function manages the recording and storage of values like: - date and time - PD level - U_{RMS} -value - Û/√2-value (lowest repetition rate for these value currently 2s)	

X.2 ICM*compact* with DSO (digital signal processor)

Fault location on cables (wide band measurement, time resolved)

Input:	'AMP IN'
Trigger:	0 to 100% of input signal step width in 3.125%
A/D Converter:	± 7bit
Samples:	100MSamples/s (T_{sample} = 10ns)
Displayed Time Window:	2 ... 80µs (200 ... 8000 Samples)
Serial Link:	56kBit/s
Specimen Cable Length:	10 to 5000m, for 80µs & v_c=140m/µs
Localization Precision:	1m + 0.1% of the cable length

XI INDEX